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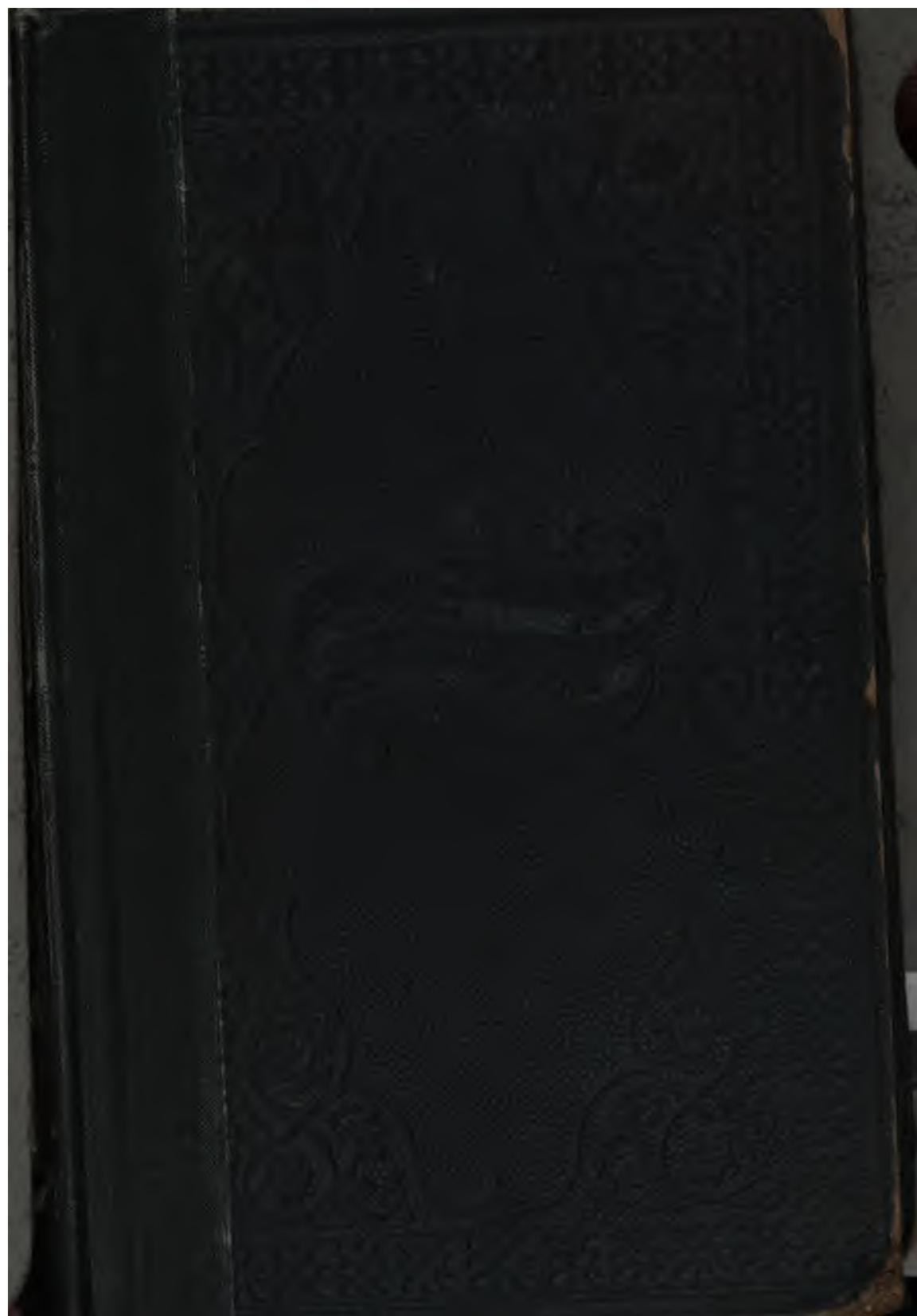
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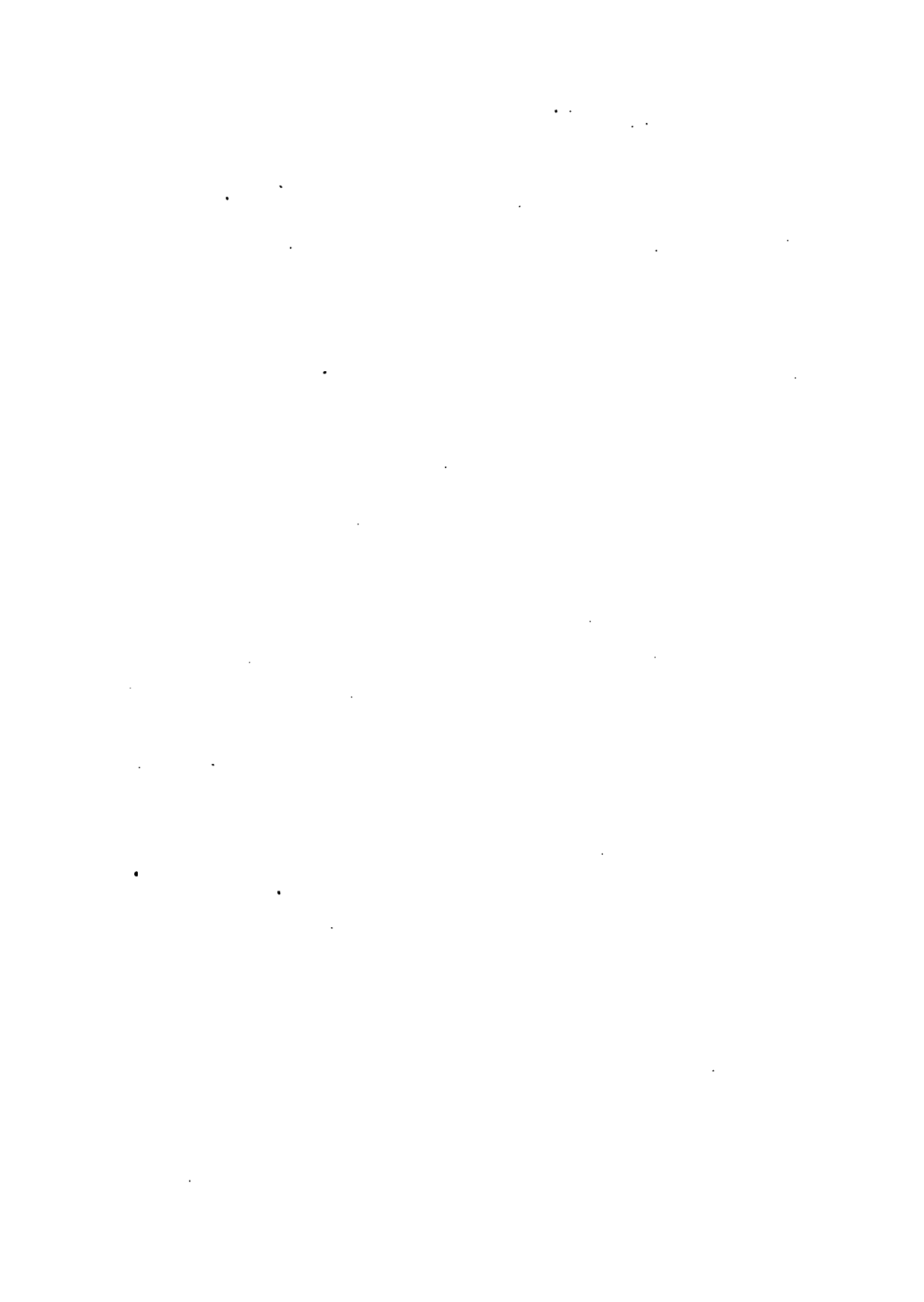
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No. 487





INTRODUCTION
TO
STRUCTURAL AND SYSTEMATIC
BOTANY,
AND VEGETABLE PHYSIOLOGY,
BEING
A FIFTH AND REVISED EDITION
OF
THE BOTANICAL TEXT-BOOK,
ILLUSTRATED WITH OVER THIRTEEN HUNDRED WOODCUTS.

BY ASA GRAY, M.D.,
FISHER PROFESSOR OF NATURAL HISTORY IN HARVARD UNIVERSITY.

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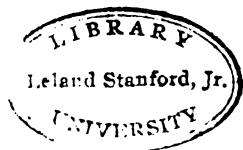
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PREFACE.

THIS compendious treatise is designed to furnish classes in the higher seminaries of learning, colleges, and medical schools, as well as private students generally, with a suitable text-book of Structural and Physiological Botany, and a convenient introduction to Systematic or Descriptive Botany, adapted to the present condition of the science. The favor with which the former editions have been received, while it has satisfied the author that the plan of the work is well adapted to the end in view, has made him the more desirous to improve its execution, and to render it a better exponent of the present state of Botany. In this view, the structural and physiological part of the work, and the chapters on the Principles of Classification and of the Natural System, have been again almost entirely rewritten, and such changes made as the advanced state of our knowledge required, or the author's continued experience in teaching has suggested. This has been done without increasing the extent of this part of the volume, which, considering the limited time devoted to the study in our colleges, &c., is found to be as full as is desirable for a text-book. Being intended as a manual for instruction merely, the Illustrations of the Natural Orders, which form the principal portion of the systematic part of the work, are brief

and general. Such a sketch, however amplified, could never take the place of a Flora, or System of Plants, but is designed merely to give a general idea of the distribution of the vegetable kingdom into families, &c., with a cursory notice of their structure, properties, and principal useful products. In applying the principles of classification, and his knowledge of the structure of plants, to the investigation of the plants that grow spontaneously around him, the student will necessarily use some local Flora, such, for example, as the author's *Manual of the Botany of the Northern United States*. For particular illustrations the botanist may advantageously consult the author's *Genera of the Plants of the United States illustrated by Figures and Analyses from Nature*, of which two volumes have been published.

About twenty-four of the wood-cuts are, by permission, selected from original sketches made for a *Report on the Trees of the United States*, in preparation by the author for the Smithsonian Institution. The numerous figures added to this edition are wholly of an original character.

The numerals enclosed in parentheses, which abound in the pages of this work, are references to other and mostly earlier paragraphs, in which the subjects or the terms in question are treated of or explained.

A full Glossary or Dictionary of Botanical Terms (combined with an Index) is added to the volume. In this, it is thought, the student will find explanations of all the technical botanical terms he is likely to meet with in descriptive works, written in the English language. The words are here accentuated, in all cases where this seemed to be needful.

Harvard University, Cambridge, Sept. 1857.

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THE
BOTANICAL TEXT-BOOK.

INTRODUCTION.

GENERAL VIEW OF THE SCIENCE.

1. BOTANY is the Natural History of the Vegetable Kingdom. The vegetable kingdom consists of those beings (called Plants) which derive their sustenance from the mineral kingdom, that is, from the earth and air, and create the food upon which animals live. The proof of this proposition will be hereafter afforded, in the chapter upon the Food and Nutrition of Plants. The vegetable kingdom, therefore, occupies a position between the mineral and the animal kingdoms. Comprehensively considered, Botany accordingly embraces every scientific inquiry that can be made respecting plants,—their nature, their kinds, the laws which govern them, and the part they play in the general economy of the world,—their relations both to the lifeless mineral kingdom below them, from which they draw their sustenance, and to the animal kingdom above them, endowed with higher vitality, to which in turn they render what they have thus derived.

2. There are three aspects under which the vegetable world may be contemplated, and from which the various departments of the science naturally arise. Plants may be considered either as individual beings; or in their relations to each other, as collectively constituting a systematic unity, that is, a vegetable kingdom; or in their relations to other parts of the creation,—to the earth, to animals, to man.

3. Under the first aspect, namely, when our attention is directed to the plant as an individual, we study its nature and structure, the

kind of life with which it is endowed, the organization through which its life is manifested ; — in other words, how the plant lives and grows, and fulfils its destined offices. This is the province of **PHYSIOLOGICAL BOTANY**. This department of the science naturally divides into two branches, namely, **Structural Botany** and **Vegetable Physiology**, which arise from the different views we may take of plants. The study of their organization belongs to **STRUCTURAL BOTANY**, which includes every inquiry respecting their structure and parts. And this may again be divided into two branches, viz. : — 1st, **VEGETABLE ANATOMY**, or **PHYTOTOMY**, the study of the minute structure of vegetables as revealed by the microscope ; and 2d, **ORGANOGRAPHY**, the study of the organs or conspicuous parts of plants, as to their external conformation ; including **MORPHOLOGY** (the study of forms), which relates to the conformation and the symmetrical arrangement of these organs, and the modifications they undergo, either in different species, according to the conditions of their existence, or in the same individual in the course of its development, — a department analogous to what is termed **Comparative Anatomy** in the animal kingdom. Thus in **Structural Botany**, whether we regard the external conformation or the minute internal structure, the plant is viewed as a piece of machinery, adapted to the accomplishment of certain ends. On the other hand, the study of this apparatus in action, endowed with life, and fulfilling the purposes for which it was intended, and also of the forces which operate in it and by it, is the province of **VEGETABLE PHYSIOLOGY**.

4. The subjects which **Physiological Botany** embraces, namely, **Vegetable Anatomy**, **Organography**, and **Physiology**, therefore, spring naturally from the study of vegetables as individuals, — from the contemplation of an isolated plant throughout the course of its existence, from germination to the flowering state, and the production of a seed like that from which the parent stock originated. These branches would equally exist, and would form a highly interesting study (analogous to human anatomy and physiology), even if the vegetable kingdom were restricted to a single species.

5. But the science assumes an immeasurably broader interest and more diversified attractions, when we look upon the vegetable creation as consisting, not of wearisome repetitions of one particular form, in itself however perfect or beautiful, but as composed of thousands

of species, all constructed upon one general plan, indeed, but this plan modified in each according to the rank it holds, and the circumstances in which it is placed. This leads to the second great department of the science, namely, **SYSTEMATIC BOTANY**, or the study of plants in their relations to one another; as forming a *vegetable kingdom*, which embraces an immense number of species, resembling each other in very various degrees, and therefore capable of being grouped into *kinds* or *genera*, into *orders*, *classes*, &c.

6. Thus arises **CLASSIFICATION**, or the arrangement of plants in systematic order, so as to show their relationships; also **SPECIAL DESCRIPTIVE BOTANY**, embracing a scientific account of all known plants, designated by proper names, and distinguished by clear and exact descriptions. Necessarily connected with these departments is **TERMINOLOGY** or **GLOSSOLOGY**, which relates to the application of distinctive names or terms to the several organs of plants, and to their numberless modifications of form, &c. The accomplishment of this object renders necessary a copious vocabulary of technical terms; for the current words of ordinary language are not sufficiently numerous or precise for this purpose. New terms are therefore introduced, for accurately expressing the great variety of new ideas to which the exact comparison of plants gives rise; and thus a technical language has gradually been formed (in this as in every other science), by which the botanist is able to describe the objects of his study with a clearness and brevity not otherwise attainable.

7. These several departments include the whole natural history of the vegetable kingdom, considered independently. But, under a third point of view, plants may be contemplated in respect to their relations to other parts of the creation; whence arises a series of interesting inquiries, which variously connect the science of Botany with Chemistry, Geology, Physical Geography, &c. Thus, the relations of vegetables with the mineral kingdom, considered as to their influence upon the soil and the air,—as to what vegetation draws from the soil and what it imparts to it, what it takes from and what it renders to the air we breathe; and, again, the relations of the vegetable to the animal kingdom, considered as furnishing sustenance to the latter, and the mutual subservience of plants and animals in the general economy of the world,—all these inquiries belong partly to Chemistry and partly to Vegetable Physiology; while the practical deductions from them lay the foundation of

scientific Agriculture, &c. The relations of plants to the earth, considered in reference to their natural distribution over its surface and the laws that regulate that distribution, especially as connected with climate, give rise to GEOGRAPHICAL BOTANY, a subject which connects Botany with Physical Geography. Under the same general department naturally falls the consideration of the changes which the vegetable kingdom has undergone in times anterior to the present state of things, as studied in the fossil remains of plants, (a contribution which Botany offers to Geology,) as well as of those changes which man has effected in the natural distribution of plants, and the alterations in their properties or products which have been developed by culture.

8. Of these three great departments of the science, that of Physiological Botany, forming as it does the basis of all the rest, first demands the student's attention.

PART I.

STRUCTURAL AND PHYSIOLOGICAL BOTANY.

9. THE principal subjects which belong to this department of Botany may be considered in the most simple and natural order by tracing, as it were, the biography of the vegetable through the successive stages of its existence,—the development of its essential organs, *root*, *stem*, and *foliage*, the various forms they assume, the offices they severally perform, and their combined action in carrying on the processes of vegetable life and growth. Then the ultimate development of the plant in flowering and fructification may be contemplated,—the structure and office of the flower, of the fruit, the seed, and the embryo plant it contains, which, after remaining dormant for a time, at length in germination develops into a plant like the parent; thus completing the cycle of vegetable life. A preliminary question, however, presents itself. To understand how the plant grows and forms its various parts, and to get a clear idea of what growth is, we must first ascertain *what plants are made of*.

CHAPTER I.

OF THE ELEMENTARY STRUCTURE OF PLANTS.

SECT. I. OF ORGANIZATION IN GENERAL.

10. The Elementary Constitution of Plants. In considering the materials of which vegetables are made, it is not necessary at the outset to inquire particularly into their *chemical* or *ultimate* composition, that which they have in common with the mineral world.

As they derive all the materials of their fabric from the earth and air, plants can possess no simple element which these do not supply. They may take in, to some extent, almost every element which is thus supplied. Suffice it for the present to say, that, of the about sixty simple substances now recognized by chemists, only four are essential to vegetation and are necessary constituents of the vegetable structure. These are *Carbon, Hydrogen, Oxygen, and Nitrogen*. Besides these, a few *earthy* bodies are regularly found in plants, in small and varying proportions. The most important of them are *Sulphur and Phosphorus*, which are thought to take an essential part in the formation of certain vegetable products, *Potassium and Sodium, Calcium and Magnesium, Silicon and Aluminum, Iron and Manganese, Chlorine, Iodine, and Bromine*. None of these elements, however, are of universal occurrence, nor are they actual components of any vegetable tissue.

11. *Their Organic Constitution.* Although plants and animals have no peculiar elements, though the materials from which their bodies spring, and to which they return, are common earth and air, yet in them these elements are wrought into something widely different from any form of lifeless mineral matter. Under the influence of *the principle of life*, in connection with which alone such phenomena are manifested, the three or four simple constituents effect peculiar combinations, giving rise to a few *organizable elements*, as they may be termed; because of them the *organized* fabric of the vegetable or animal is directly built up. This fabric is in a good degree similar in all living bodies; the solid parts, or *tissues*, in all assuming the form of membranes, arranged so as to surround cavities, or form the walls of tubes, in which the fluids are contained. It is called *organized structure*, and the bodies so composed are called *organized bodies*, because such fabric consists of parts co-operating with each other as instruments or *organs* adapted to certain ends, and through which alone the living principle, under whose influence the structure itself was built up, is manifested in the operations which the plant and animal carry on. There is in every organic fabric a necessary connection between its conformation and the actions it is destined to perform. This is equally true of the minute structure, or tissues, as revealed by the microscope, and of the larger *organs* which the tissues form in all plants and animals of the higher grades, such as a leaf, a petal, or a tendril, a hand, an eye, or a muscle. The term *organization* formerly referred to the possession of organs in this larger

sense, that is, of conspicuous parts, or members. It is now applied as well to the intimate structure of these parts, themselves made up of smaller organs through which the vital forces directly act.

12. *Distinctions between Minerals and Organized Beings.* In no sense can mineral bodies be said to have organs, or parts subordinate to a whole, and together making up an individual, or an organized structure in any respect like that which has just been spoken of, and is soon (as regards plants) to be particularly described. Without attempting to contrast mineral or unorganized with organized bodies in all respects, we may briefly state that the latter are distinguished from the former,— 1. By *parentage*: plants and animals are always produced under the influence of a living body similar to themselves, or to what they will become, in whose life the offspring for a time participates; while in minerals there is no relation like that of parent and offspring, but they are formed directly, either by the aggregation of similar particles, or by the union of unlike elements combined by chemical affinity, independent of the influence, and utterly irrespective of the previous existence, of a similar thing. 2. By their *development*: plants and animals develop from a germ or rudiment, and run through a course of changes to a state of maturity; the mineral exhibits no phases in its existence answering to the states of germ, adolescence, and maturity,—has no course to run. 3. By their *mode of growth*: the former increasing by processes through which foreign materials are taken in, made to permeate their interior, and deposited *interstitially* among the particles of the previously existing substance; that is, they are nourished by food;—while the latter are not nourished, nor can they properly be said to grow at all; if they increase in any way, it is merely by *juxtaposition*, and because fresh matter happens to be deposited on their external surface. 4. By the power of *assimilation*, or the faculty that plants and animals alone possess of converting the proper foreign materials they receive into their own peculiar substance. 5. Connected with assimilation, as a part of the function of nutrition, which can in no sense be predicated of minerals, is the state of *internal activity and unceasing change* in living bodies; these constantly undergoing decomposition and recombination, particles which have served their turn being continually thrown out of the system as new ones are brought in. This is true both of plants and animals, but more fully of the latter. The mineral, on the contrary, is in a state of

permanent internal repose: whatever changes it undergoes are owing to the action of some extraneous force, not to any inherent power. This holds true even in respect to the chemical combinations which occur in the mineral and in the organic kingdoms. In the former they are stable; in the latter they are less so in proportion as they are the more under the influence of the vital principle: as if in the state of unstable equilibrium, a comparatively slight force induces retrograde changes, through which they tend to reassume the permanent mineral state. 6. Consequently the *duration* of living beings is limited. They are developed, they reach maturity, they support themselves for a time, and then perish by death, sooner or later. Mineral bodies have no life to lose, and contain no internal principle of destruction. Once formed, they exist until destroyed by some external power; they lie passive under the control of physical forces. As they were formed irrespective of the pre-existence of a similar body, and have no self-determining power while they exist, so they have no power to determine the production of like bodies in turn. The organized being may perish, indeed, from inherent causes; but not until it has given rise to new individuals like itself, to take its place. The faculty of *reproduction* is, therefore, an essential characteristic of organized beings.

13. *Individuals.* The mass of a mineral body has no necessary limits; a piece of marble, or even a crystal of calcareous spar, may be mechanically divided into an indefinite number of parts, each one of which exhibits all the properties of the mass. But plants and animals exist as *individuals*; that is, as *beings*, composed of parts which together constitute an independent whole, that can be divided only by mutilation. Each owes its existence to a parent, and produces similar individuals in its turn. So each individual is a link of a chain; and to this chain the natural-historian applies the name of

14. *Species.* The idea of species is therefore based upon this succession of individuals, each deriving its existence, with all its peculiarities, from a similar antecedent one, and transmitting its form and other peculiarities essentially unchanged from generation to generation. By species we mean abstractly the *type* or original of each sort of plant, or animal, thus represented by a perennial succession of like individuals: or, concretely, the species is the sum of such individuals.

15. *Life.* All these peculiarities of organized, as contrasted with inorganic bodies, will be seen to depend upon this: that the former are living beings, or their products. The great characteristic of plants and animals is *life*, which these beings enjoy, but minerals do not. Of the essential nature of the vitality which so controls the matter it becomes connected with, and of the nature of the connection between *the living principle* and *the organized structure*, we are wholly ignorant. We know nothing of life except by the phenomena it manifests in organized structures. We have adverted only to some of the most universal of these phenomena, those which are common to every kind of organized being. But these are so essentially different from the manifestations of any known physical force, that we are compelled to attribute them to a special principle. We may safely infer, however, that life is not a product, or result, of the organization; but is a force manifested in matter, which it controls and shapes into peculiar forms,—into an apparatus, in which means are manifestly adapted to ends, and by which results are attained that are in no other way attainable. As we rise in the scale of organized structure from plants through the various grades of the animal creation, the superadded vital manifestations become more and more striking and peculiar. But the fundamental characteristics of living beings,—those which all enjoy in common, and which necessarily give rise to all the peculiarities above enumerated (12),—are reducible to two, viz.:—1. the power of *self-support*, or *assimilation*, that of nourishing themselves by taking in surrounding mineral matter and converting it into their own proper substance; by which individuals increase in bulk, or grow, and maintain their life: 2. the power of *self-division* or *reproduction*, by which they increase in numbers and perpetuate the species.*

16. *Difference between Vegetables and Animals.* The distinction between vegetables and minerals is therefore well defined. But the line of demarcation between plants and animals is by no means so readily drawn. Ordinarily, there can be no difficulty in distinguishing a vegetable from an animal. All the questionable

* A single striking illustration may set both points in a strong light. The larva of the flesh-fly possesses such power of assimilation, that it will increase its own weight two hundred times in twenty-four hours; and such consequent power of reproduction, that Linnaeus perhaps did not exaggerate, when he affirmed that "three flesh-flies would devour the carcass of a horse as quickly as would a lion."

cases occur on the lower confines of the two kingdoms, which exhibit forms of the greatest possible simplicity of structure, and of a minuteness of size that baffles observation. Even here the uncertainty may be attributable rather to the imperfection of our knowledge, than to any confusion of the *essential* characteristics of the two kinds of beings. If we cannot absolutely define them, or, at least, cannot always apply the definition to the actual and certain discrimination of the lowest plants from the lowest animals, we may indicate the special functions and characters of each. The essential characteristics of vegetables doubtless depend upon the position which the vegetable kingdom occupies between the mineral and the animal, and upon the general office it fulfils. Plants, as stated at the outset (1), are those organized beings that live directly upon the mineral kingdom,—upon the surrounding earth and air. They alone convert inorganic, or mineral, into organic matter; while animals originate none, but draw their whole sustenance from the organized matter which plants have thus elaborated. Plants, having thus the most intimate relations with the mineral world, are generally fixed to the earth, or other substance upon which they grow, and the mineral matter on which they feed is taken directly into their system by absorption from without, and is assimilated under the influence of light in organs exposed to the air; while animals, endowed with volition and capable of responding promptly to external impressions, have the power of selecting the food ready prepared for their nourishment, which is received into an internal reservoir or stomach. The permanent fabric of plants is composed of only three elements, Carbon, Hydrogen, and Oxygen. The tissue of animals contains an additional element, viz. Nitrogen. Plants, as a necessary result of assimilating their inorganic food, decompose carbonic acid and restore its oxygen to the atmosphere. Animals in respiration continually recombine carbonic acid, at the expense of the oxygen of the atmosphere and the carbon of plants. These peculiarities will be explained and illustrated in the progress of this work.

SECT. II. OF THE CELLS AND CELLULAR TISSUE OF PLANTS.

17. THE question recurs, What is the organized fabric or tissue of plants, and how is vegetable growth effected? The stem, leaves,

and fruit appear to ordinary inspection to be formed of smaller parts, which are themselves capable of division into still smaller portions. Of what are these composed?

18. **Cellular Structure.** To obtain an answer to this question, we examine, by the aid of a microscope, thin slices or sections of any of these parts, such, for example, as the young rootlet of a seedling plant. A magnified view of such a rootlet, as in Fig. 1, presents on the cross-section the appearance of a network, the meshes of which divide the whole space into more or less regular cavities. A part of the transverse slice more highly magnified (Fig. 2) shows the structure with greater distinctness. A perpendicular slice (Fig. 3) exhibits somewhat similar meshes, showing that the cavities do not run lengthwise through the whole root without interruption. In whatever direction the sections are made, the cavities are seen to be equally circumscribed, although the outlines may vary in shape. Hence, we arrive at the conclusion, that the fabric, or *tissue*, consists of a multitude of separate cavities, with



closed partitions; forming a structure not unlike a honeycomb. This is also shown by the fact, that the liquid contained in a juicy fruit, such as a grape or currant, does not escape when it is cut in two. The cavities being called **CELLS**, the tissue thus constructed is termed **CELLULAR TISSUE**. When the body is sufficiently translucent to be examined under the microscope by transmitted light, this structure may usually be discerned without making a section.

FIG. 1. Portion of a young root, magnified. 2. A transverse slice of the same, more magnified. 3. A smaller vertical slice, magnified.

FIG. 4. Cellular tissue from the apple, as seen in a section. 5. Some of the detached cells from the ripe fruit, magnified.

FIG. 6. Portion of a hair from the filament of the Spider Lily (*Tradescantia*), magnified: a, vestige of the nucleus.

We may often look directly upon a delicate rootlet (as in Fig. 1), or the petal of a flower, or a piece of thin and transparent sea-weed, and observe the closed cavities, entirely circumscribed by nearly transparent membranous walls.

19. Does this *cellular tissue* consist of an originally homogeneous mass, filled in some way with innumerable cavities? Or is it composed of an aggregation of little bladders, or sacs, which by their accumulation and mutual cohesion make up the root or other organ? Several circumstances prove that the latter is the correct view. 1. The partition between two adjacent cells is often seen to be double; showing that each cavity is bounded by its own special walls.



2. There are vacant spaces often to be seen between contiguous cells, where the walls do not entirely fit together. These *intercellular spaces* are sometimes so large and numerous, that many of the cells touch each other at a few points only; as in the green pulp of leaves (Fig. 7). 3. When a portion of any young and tender vegetable tissue, such as an Asparagus shoot, is boiled, the elementary cells separate, or may readily be separated by the aid of fine needles, and examined by the microscope. 4. In pulpy fruits, as in the apple, the walls of the cells, which at first cohere together, spontaneously separate as the fruit ripens (Fig. 4, 5).

20. The vegetable, then, is constructed of these cells or vesicles, much as a wall is built up of bricks. When the cells are separate, or do not impress each other, they are generally rounded or spherical. By mutual pressure they become many-sided. In a mass of spheres each one is touched by twelve others; so, if equally impressed in every direction, the yielding cells, flattening each other at the points of contact, become twelve-sided; and in a section, whether transverse (as in Fig. 2) or longitudinal (as in



FIG. 7. A magnified section through the thickness of a leaf of *Illicium Floridanum*, showing the irregular spaces or passages between the cells, which are small in the upper layer of the green pulp, the cells of which (placed vertically) are well compacted, so as to leave only minute vacuities at their rounded ends; but the spaces are large and copious in the rest of the leaf, where the cells are very loosely arranged. *a*, The epidermis or skin of the upper, *b*, of the lower surface of the leaf, composed of perfectly combined and thick-walled cells.

FIG. 8. View of a twelve-sided cell, detached entire, from tissue like that of Fig. 9.

Fig. 3), the meshes consequently appear six-sided. If the organ is growing in one direction more than another, the cells commonly lengthen more or less in that direction. It is not necessary to detach a cell in order to ascertain its shape; that may usually be inferred from the outlines of the section in two or three directions.

21. The shape of cells, therefore, when they compose a tissue, depends very much upon the way in which they are arranged and press upon each other. When separate, as they are in the simplest vegetables, or when nearly free from each other, like the hairs on the surface of many plants, they determine their own form by their mode of growth, and assume a great variety of shapes, some of which are shown in the following illustrations. The natural and primitive form may be said to be roundish or spherical. By increased growth in one direction they become oblong or cylindrical, or, when still more extended, they become tubes. Of this kind are the hair-like prolongations on the surface of young rootlets (shown just beginning in Fig. 1, and more elongated in Fig. 135-137); and the fibres of cotton are slender hairs, consisting of single, very long cells, growing on the surface of the seed.



22. The walls of young cells are transparent and colorless. The various colors which the parts of the plant present, the green of the foliage, and the vivid hues of the corolla, do not belong to the tissues themselves, but to the matters of different colors which the cells contain (92). As they become older, the walls often lose most of their transparency, and even acquire peculiar colors, as in the heart-wood of various trees.

23. The cells vary greatly in size, not only in different plants, but in different parts of the same plant. The largest are found in aquatics, and in such plants as the Gourd, where some of them are as much as one thirtieth of an inch in diameter. Their ordinary diameter in vegetable tissue is between $\frac{1}{200}$ and $\frac{1}{100}$ of an inch.

FIG. 9. A small portion of the tissue of pith, seen both in transverse and longitudinal section, much magnified.

The smaller of these sizes would allow of as many as 1728 millions of cells in the compass of a cubic inch!

24. Some idea may be formed respecting the rate of their production, by comparing their average size in a given case with the known amount of growth. Upon a fine day in the spring, many stems shoot up at the rate of three or four inches in twenty-four hours. When the Agave or Century-plant blooms in our conservatories, its flower-stalk often grows at the rate of a foot a day; it is even said to grow with twice that rapidity in the sultry climate to which it is indigenous. In such cases, new cells must be formed at the rate of several millions a day. The rapid growth of Mushrooms has become proverbial. A gigantic species of Puff-ball has been known to attain the size of a large gourd during a single night: in this case the cells of which it is composed are computed to have been developed at the rate of three or four hundred millions per hour. But this rapid increase in size is owing, in great part, to the expansion of cells already formed.

25. *The Cell as a living Organism.* Thus far we have considered only the membrane or permanent wall of the cell,—that which makes up the tissue or fabric of plants, and which remains unaltered, and performs some of its offices even long after life has departed. But we should now regard the cell as a living thing, and consider what the wall encloses, and what operations are effected in it. For the whole life of the plant is that of the cells which compose it; in them and by them its products are elaborated, and all its vital processes carried on.

26. A young, living, vitally active cell consists,—1st, of the membrane or permanent wall, already described; 2d, of a delicate mucilaginous film, lining the wall, called by Mohl the *primordial utricle*; 3d, most commonly the centre of the cell, and sometimes the greater part of the cavity, is occupied by the *nucleus*, a soft solid or gelatinous body; and 4th, the space between the nucleus and the lining membrane is filled at first by a viscid liquid, called *protoplasm*, having an abundance of small granules floating in it. As the cell enlarges by the growth and expansion of its walls, the space between the latter and the nucleus becomes filled with watery sap, leaving the protoplasm merely as a viscid coating of the inside of the primordial utricle, and of the nucleus, if this remains.

27. The cell-membrane, or proper wall of the cell, is chemically composed of the three elements, carbon, hydrogen, and oxygen,

and has the same composition (when pure) in all plants. This substance—the general material of vegetable fabric—is called *Cellulose*. Its chemical composition is Carbon 12, Hydrogen 10, and Oxygen 10. It is insoluble in water, alcohol, ether, and dilute acids, and, like starch, it turns blue when acted upon by iodine, aided by sulphuric acid. The primordial utricle, or delicate lining of the cell, appears to have the same composition as protoplasm. It may be regarded as an exterior portion of the mucilaginous protoplasm, which has acquired the consistence of a very soft membrane. In addition to the three elements, carbon, hydrogen, and oxygen, protoplasm contains nitrogen, in considerable quantity. It is colored yellow by iodine, and is coagulated by alcohol and acids. The substance of which it principally consists is named by chemists *Proteine*, and is known among vegetable products under various forms, viz. as diastase, gluten, fibrine, vegetable albumen, and the like. Such being the nature and the parts of the cell, we may now consider

28. *Its Formation and Growth.* Under this head we may briefly explain, as far as we are able,—1st, how cells are originated; and 2d, how they are multiplied.

29. *Original Cell-Formation.* Cells are originated only within other cells, or at least in matter which has been contained in and elaborated by them. They appear to be formed in the following manner. A portion of the elaborated or organizable matter, which abounds in the fluid contents of living cells, condenses into a soft solid, or half-solid and more or less transparent mass, usually of a globular or oval shape, the *nucleus*: around this nucleus a portion of protoplasm accumulates; a denser film of the same substance forms on the surface of the protoplasm, giving the mass a definite outline; this is the *primordial utricle*: upon this a layer of cellulose is soon deposited, making the *cell-membrane*. The nuclei in such cases are very minute, and either few or many of them may be formed in one parent cell, and be developed in this way into new cells, which are, at least at first, of small size as compared with the parent cell (Fig. 88). A variation of this mode occurs in many of the lower Algae, where a considerable portion of the contents of a cell condenses into a rounded mass, the surface becomes coated with a layer of protoplasm or primordial utricle, and this with a membrane of cellulose, completing the cell. Thus, in *Vaucheria* the whole green contents at the end of certain branches condense into a

globular mass (Fig. 89), which at length is coated with cell-membrane, and so becomes a cell of considerable size. In *Zygnema* (Fig. 635) the whole contents of two cells are united, and give rise in a similar way to one new cell.

30. In the higher or flower-bearing division of plants, this process of original or *free* cell-formation occurs only in the sac in which the embryo is formed. The first cell of the embryo originates in this way; but all the subsequent growth is effected by a different process. In the simplest grade of plants it occurs more frequently, but only in the formation of those bodies which in them take the place and fulfil the office of seeds; that is, which serve for reproduction.

31. It appears, therefore, that the azotized or nitrogenous material, the proteine, plays the most important part in the formation of cells. The layer of protoplasm, with its delicate coating, the primordial utricle, precedes the proper cell-membrane, and in some unexplained way causes the latter to be deposited on its surface. And these soft nitrogenous parts are the seat of the whole vital activity of the cell. The wall of cellulose may be regarded as a kind of protecting coat or shell, which constitutes the permanent fabric of the plant, but is alive only so long as the living protoplasmic lining remains.

32. In a growing young cell, the walls enlarge much faster than the nucleus, and the latter soon ceases to grow at all. It is therefore left in the centre, or else remains adherent to the wall on one side, where traces of it may often for a long time be detected; or more commonly it dissolves and disappears altogether. At length, in older cells, the liquid contents and the protoplasmic lining also disappear, and only the walls of cellulose remain as the permanent vegetable fabric. The fabric of plants, however, as has already been stated, is not built up by original cell-formation, but by

33. *Cell-Multiplication.* A living cell, formed in whatever manner, has the power of multiplying itself by dividing into two, these again into two more, and so on. By this process the single cell, which each vegetable begins with, gives rise to the embryo or rudimentary plantlet contained in a seed; and by it the embryo in germination develops into a seedling, and the seedling into the herb, shrub, or tree. Vegetable growth accordingly consists, — 1st, of the growth or expansion of each cell up to its full size, which ordinarily is very soon attained; and 2d, of what is called their *merismatic multiplication*.

tion, namely, the successive division of cells into two. This takes place only when they are young and active, and mostly before they are full-grown. It is effected by the formation of a partition across the cavity of the cell, dividing it into two (Fig. 10-14). In this way, a single cell gives rise to a row of connected cells, when the division takes place in one direction only; or to a plane or solid mass of such cells, when it takes place in two or more directions, thus producing a tissue.

34. In this multiplication of cells by division, as in the original formation of a cell, the contents and the protoplasmic lining play the most important part. The nucleus, when present, as it commonly is, first divides into two (Fig. 11); then the lining membrane, or primordial utricle, is gradually constricted or infolded at the line of division, which, soon meeting in the centre, separates the whole contents into two parts by a delicate partition; upon this a layer of cellulose is deposited as a permanent wall, which completes the transformation of one cell into two (Fig. 21, 22).

35. Cells multiplying in this way, and remaining united, build up a row or a surface of cells, or a solid tissue, according to the mode of division. But in many of the simplest plants, growing in water, the cells separate as they form, and become independent. A microscopic plant very common in shallow pools in early spring, forming slimy green masses, well illustrates this, as shown in Figures 15-19. At each step of this multiplication new cell-membranes are formed, and the old one, for instance, the wall of Fig. 15 and the common envelope of the two in Fig. 17,



FIG. 10. A young cell, — the first cell of an embryo, — with its nucleus in the centre. 11. The same, with its nucleus divided into two, and a cross-partition beginning to form. 12. The partition completed, so converting the first cell into two. 13. The lower one again divided into two, making three cells in a row. 14. The fourth cell converted into four by a division in two directions, forming seven cells in all.

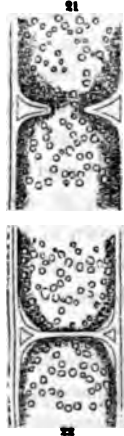
FIG. 15. A single cell, or plant of a kind of *Palmella*, magnified. 16. The same dividing, and, 17, completely separated into two. 18. Each of these dividing in the opposite direction, four cells are produced. 19. Each of these again dividing into four, they produce a cluster of sixteen cells.

one of the four in Fig. 18, forms a part of the thickness of the wall of each, or is destroyed by the distention, or else (as in the present instance) is dissolved into a jelly. A slight modification of this process occurs in



36. Free Cell-Multiplication within

a Mother-Cell, which is intermediate in character between original cell-formation and ordinary cell-multiplication. Here the whole contents of a living cell, by constriction or infolding of the primordial utricle, divide into two or four parts (as in Fig. 81-83), and these may be again divided;—each portion has a coat of cellulose deposited over its surface, and thus so many separate cells are produced, lying loose in the cavity of the mother-cell, whose thin and now dead cellulose-wall, which is all that is left of it, usually disappears sooner or later, or is broken up by the growth of the new crop of cells within. In this way are formed the grains of pollen in the anther, and the spores, or bodies which answer to seeds, in the higher grades of Flowerless Plants.



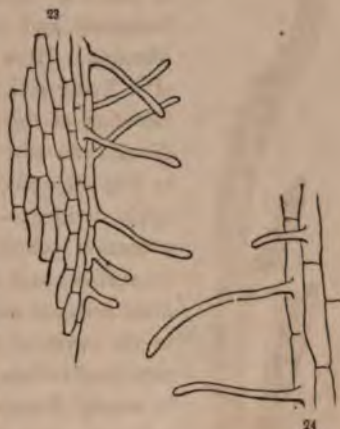
37. Cell-Growth. By appropriating assimilated matter, the young cell increases in size until it attains its full growth; its walls, as they expand and enclose a greater space, not diminishing, but rather increasing in thickness. Therefore it not merely enlarges, but grows. If it grows equally in all directions, and is not pressed upon on any side, it keeps a spherical form; if it grows more in one direction than in any other it becomes oblong or cylindrical. In this way a cell is sometimes drawn out into a slender tube; of which the fibres of cotton, and the cells of fibrous bark (Fig. 49) are good examples. In the simplest plants, cells sometimes continue to elongate almost

FIG. 20. The branching summit of a plantlet of *Conferva glomerata*, magnified; after Mohl. The plant consists of a row of cells, filled with green grains floating in liquid: the long cell at the upper end is seen in the process of dividing into two, at *a*, by constriction of the primordial utricle.

FIG. 21. A portion of the same at *a*, more magnified, showing the formation of the partition. 22. Same, with the partition completed.

indefinitely from one end, by a sort of *gemmation* or *budding growth*, while all the rest remains stationary, or while the opposite extremity is dead or decaying. Fig. 20 would represent a case of the kind, except that partitions form, as the upper end grows on, dividing the tube into a row of cylindrical cells. Sometimes a new point of growth commences on the side of a cell, so giving rise to

38. Branching Cells. The hair-like bodies that copiously appear on the surface of young rootlets furnish examples of the kind, as is shown in Fig. 1, 23, 24. More conspicuous examples are furnished by certain Alge of the simplest structure, where the cell branches profusely as it elongates, but the tubes are all perfectly continuous throughout; as in *Botrydium* (Fig. 88), where an originally spherical cell is extended and ramified below in the fashion of a root; in *Vaucheria* (Fig. 89),



where a slender tube forks or branches sparingly; and in *Bryopsis* (Fig. 91), where numerous branches are symmetrically arranged in two opposite rows, like the plume of a feather. In these cases, the

fully developed plant, with all its branches, is only one proliferous cell, extended from various points by this faculty of continuous budding growth. The mycelium or spawn of Mushrooms, and the intricate threads of Moulds (Fig.



92-94) are formed of very attenuated branching cells. And in Lichens and many Fungi, cells of this kind are densely interwoven into a filamentous tissue (Fig. 25).

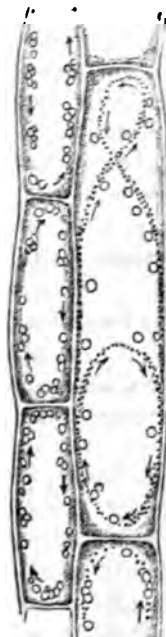
39. Cyclosis or Circulation in Cells. In all young cells, probably, at least at some period, the fluid protoplasm interposed between the cell-walls and the watery sap is in a state of movement. Under

FIG 23 Magnified cellular tissue from the rootlet of a seedling Maple; some of the external cells growing out into root-hairs. 24 A few of the cells more highly magnified.

FIG 25 Entangled, filamentous, branching cells from the fibrous tissue of the Reindeer Lichen (*Cladonia rangiferina*), magnified.

the microscope, currents, rendered more visible by the contained granules or solid atoms, are seen flowing around the cell, or around some portion of its periphery, in a circuit which returns upon itself. The cause of this curious phenomenon and the object it subserves are unknown; but it is doubtless a vital circulation, and not a mechanical movement. In most plants it is not to be seen in

mature cells. But it may be observed in many water-plants when full-grown, and in the hairs on the surface of a great variety of land-plants. The string of bead-like cells which compose the jointed hairs of the common Spider Lily (*Tradescantia*, Fig. 6) show this circulation well, under a magnifying power of about four hundred diameters. With this power, a set of thread-like currents may be seen to move between the cell-wall and the enclosed colored contents, traversing the cell in various directions, without much regularity, except that the streamlets appear to radiate from, and return to, the nucleus. The large stinging hairs of Nettles, and the bristles on the ovary of *Circea*, show this circulation very well. In the latter, instead of the separate and slender streamlets of *Tradescantia*, we perceive a broad and continuous stream flowing up on one side of the long cell, around the summit, and down the opposite side. This circulation may be more readily observed in the cells of many aquatic plants. In *Chara* and *Nitella*,—plants composed of large



cells lined with green granules,—a magnifying power of fifty or one hundred diameters shows the circulation very well. And the leaves of *Vallisneria spiralis* (the Tape-grass or Eel-grass of fresh water) are still more beautiful objects, when magnified from two to four hundred diameters. Through their nearly transparent walls, a current of protoplasm, usually carrying with it some globular loose grains of chlorophyll, may be seen coursing up the entire breadth of the wall of each cell, across its summit, down the opposite side, and across the other end to complete the circuit; and often the current is strong enough to set the large nucleus, or a central mass

FIG. 26. A few cells of the leaf of *Najas flexilis*, highly magnified, showing the circulation; the direction of the currents indicated by arrow-heads. (Drawn by H. J. Clark.)

of green grains, into revolution. The circulation is more active in the subjacent than in the superficial layer of cells, although occasionally conspicuous in the latter: it is stopped or retarded by lowering, and accelerated by raising the temperature. The motion often appears to be quite rapid; but it should be remembered that this is magnified as well as the object. Mohl states it to be very slow, not more than the $\frac{1}{500}$ of a line per second in the hairs of *Tradescantia*. But in *Vallisneria* the green grains sometimes complete the circuit of a cell of the ordinary size in less than twenty seconds; and in the bristles on the fruit of *Circæa*, which are half a line long, Mr. H. J. Clark has seen the revolution completed in about a minute. The circulation in one cell is totally independent of that in the adjacent ones. The current is commonly seen to flow in opposite directions on the two sides of a partition, or to move on one side when quiescent on the other. Cyclosis, whatever its nature may be, evidently has nothing to do with the

40. *Transference of Fluid from Cell to Cell.* All cells, at least when young and living, have perfectly closed walls. There is no passage from one to another through visible openings or pores, although such openings may be formed in older parts. Nevertheless fluids do permeate cell-walls, as they do all organic membranes. And in this way water, along with other matters which the roots absorb, is carried up into the leaves even of the topmost bough of a tree, passing in its course through many millions of apparently watertight partitions. However governed by forces inherent in the plant, the actual transference of fluids from one cell to another takes place in obedience to a physical law, i. e. by the process which has been named *Endosmose* or *Endosmosis*,* and which operates in dead parts

* *Endosmose* and *exosmose* are names given by Dutrochet (a French physiologist) to a physical process of permeation and interchange which takes place in fluids, according to the following law, briefly stated. When two liquids of unequal density are separated by a permeable membrane, the lighter liquid or the weaker solution will flow into the denser or stronger, with a force proportioned to the difference in density (*endosmosis*); but at the same time, a smaller portion of the denser liquid will flow out into the weaker (*exosmosis*). Thus, if the lower end of an open tube, closed with a thin membrane, such as a piece of moistened bladder, be introduced into a vessel of pure water, and a solution of sugar in water be poured into the tube, the water from the vessel will shortly be found to pass into the tube, so that the column of liquid it contains will increase in height to an extent proportionate to the strength of the solution. At the same time, the water in the vessel will become

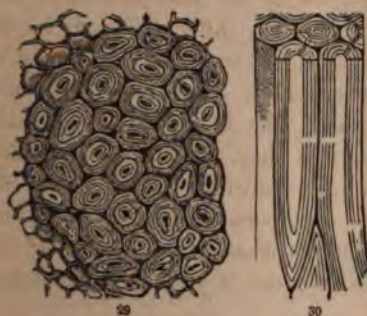
as well as in living ones. The law is, that when two fluids of unequal density are separated by an organic membrane, or by any thin and porous partition, an interchange takes place,—more or less rapidly according to the thinness of the intervening partition and the difference in the density of the fluids on the two sides,—a small quantity of the denser fluid passing into the lighter, but a much larger portion of the lighter passing into the denser; and this continues until the two fluids are brought to the same density. Hence, as the cells of a living plant always contain organizable or assimilated matter (mucilage, protoplasm, &c.), which especially abounds in young and growing parts, the cells of the rootlets are always able to imbibe the ordinary moisture which is presented to them in the soil; and by diminishing the portion of water, or in any other way increasing the density of the liquid contents of the cells of any part of the plant, a flow may be attracted into them.

41. *Increase of Cell-walls in Thickness.* Up to a certain point, the walls of cells thicken as they grow by the incorporation of new matter *interstitially* into their substance. After attaining, for the most part rapidly, a definite size, the cell ceases to enlarge, and its wall no longer incorporates new materials. Some cells remain with exceedingly thin and delicate walls. But in most cells that make part of the permanent structure of a plant, the cell-membrane continues to thicken long after it has ceased to enlarge. Then the new matter can no longer be incorporated with the old; but the thickening is now effected by its deposition on the inner surface of the original membrane, between it and the protoplasmic

slightly sweet; showing that a small quantity of sirup has passed through the pores of the membrane into the water without, while a much larger portion of water has entered the tube. The water will continue to enter the tube, and a small portion of sirup to leave it, until the solution is reduced to the same strength as the liquid without. If a solution of gum, salt, or any other substance, be employed instead of sugar, the same result will take place. If the same solution be employed both in the vessel and the tube, no transference or change will be observed. But if either be stronger than the other, a circulation will be established, and the stronger solution will increase in quantity until the two attain the same density. If two different solutions be employed, as, for instance, sugar or gum within the tube, and potash or soda without, a circulation will in like manner take place, the preponderance being *towards* the denser fluid, and in a degree proportionate to the difference in density. Instead of animal membrane, any vegetable matter with fine pores, such as a thin piece of wood, or even a porous mineral substance, may be substituted, with the same result.

lining. Every degree of this secondary deposition occurs, from a slight increase in the thickness of the membrane to the filling up of the greater part of the cavity of the cell. Any hard wood furnishes illustrations of this. Indeed, the difference between *sap-wood* and *heart-wood* in trees is principally owing to the increase of this deposit, which converts the former into the latter; as may be seen by comparing, under the microscope, the tissue of the older with that of the newest rings of wood, taken from the same tree. Figures 196-199 show this in a piece of oak wood. Fig. 29 represents a highly magnified cross-section of some wood-cells from the bark of a Birch, with

their calibre almost obliterated in this way. It is by the same process that the stone of the peach, cherry, &c. acquires its extreme hardness. Similar indurated cells of the same kind are met with



even in the pulp of some fruits, as in the gritty grains, which every one has noticed in the flesh of certain pears, especially of the poorer sorts. A section of a few cells of the kind is represented in Fig. 27, with their cavity much reduced and rendered very irregular by this internal incrustation. Similar cells may

be found in some parts of the tissue even of such juicy fruits as the cranberry and the blueberry (Fig. 28).

42. The thickening matter, when pure, is of the same nature as the original membrane of the cell, that is, it consists of cellulose (27). But with this are mingled some mineral matters,—small quantities of which must needs be dissolved in the water which the plant imbibes by its roots, and be deposited in the cells of the

FIG. 27. Magnified section of the gritty cells of the pear; the cavity almost filled with an internal deposit. 28. Similar cells found in the pulp of the blueberry (*Vaccinium corymbosum*).

FIG. 29. Highly magnified cross-section of a bit of the old liber of the bark of the Birch; the tubes nearly filled with a deposit of solid matter in concentric layers. (From Link.)

FIG. 30. Highly magnified wood-cells (seen in transverse and longitudinal section), from the root of the Date Palm; showing the thickening deposit in layers, and some connecting canals or pits. (From Jussieu, after Mirbel.)

wood, and especially in those of the leaves, where much of the water escapes by evaporation, — and sometimes certain coloring matters also, such as give the different tints to heart-wood, &c. Even when purified as much as possible from all admixture of foreign materials, the secondary deposit is said to differ a little from cellulose, or original cell-membrane, in containing a somewhat larger proportion of carbon and hydrogen: it is therefore richer in combustible matter. Forming as it does the principal part of the weight of wood (*lignum*), it has received the name of *Lignine* (also that of *Sclerogen*); but it is only cellulose a little modified. This difference in chemical composition, however, shows why the hard woods, such as hickory and oak, which abound in this lignified deposit, should be more valuable for fuel, weight for weight, than the soft woods, which have little of it; at least, when the latter are not charged with resinous matter.*

43. The section of the wall of a cell thickened by internal deposit, when moderately magnified, commonly appears to be homogeneous and uniform. But under a high magnifying power it may often be distinguished more or less distinctly into successive concentric layers (Fig. 27–31). However this may be, it rarely happens that the thickening deposit is spread evenly over the whole inner surface of a cell. It is commonly interrupted or much thinner at some places, so as to give the diminished cavity of the cell very irregular outlines (as in Fig. 27, 28); or else it is wanting at certain small and definite spots, which, being more transparent, when looked down upon from the outside appear like holes or pores (Fig. 32, 56, 57) or slits (Fig. 58, 59), according to their shape. In this way are formed the various

44. **Markings of the Walls of Cells.** These, whether in the form of bands, spiral lines, dots, or apparent pores, all arise from the unequal

* From the manner in which the thickening takes place, it would appear that the innermost layers must always be the most recent. But M. Trécul has convinced himself that the primary cell-membrane sometimes produces a secondary one outside of itself, as well as on the inside, so that the original cell-wall is intermediate. And also, that, when the thickening deposit is wholly within the primary wall, the intermediate layers are occasionally secreted in some way by the outer or inner ones, and therefore more recent than the inner. Unlikely as all this seems, M. Trécul's investigations are entitled to great attention. His elaborate memoir, upon *Secondary Formations in Cells*, is published in the *Annales des Sciences Naturelles*, 4th ser. Vol. II. 1854.

distribution of the secondary deposit. They are portions of the walls which are either thinner or thicker than the rest. These markings display the greatest variety of forms, many of them of surpassing elegance. The principal kinds occur with perfect uniformity in each species or family, and in definite parts of the plant; so that, in a multitude of cases, the sort of plant may be as certainly identified by the minute sculpture of its cells alone, as by more conspicuous external characters. They are preserved even when the tissue is fossilized, and the external form, with every outward appearance of organization, is obliterated. Through thin slices and other contrivances, the hidden structure is revealed under the microscope, and thus the true nature of the earth's earliest vegetation may be often satisfactorily made out. In this way, and by taking advantage of the fact, that the secondary deposits in the cells contain a good deal of mineral matter, which is left behind in the ashes, Professor Bailey was able first to discover vegetable structure in anthracite coal.* The simplest and commonest markings are those which appear as pores or holes, but are really

45. Dots or Pits, such as those on the cells of the pith of Elder (Fig. 38), and



* See Silliman's American Journal of Science and Arts, New Series, Vol. I.

FIG. 31. Magnified cross-section of a small portion of heart-wood of the Plane-tree or Buttonwood (*Platanus occidentalis*). 32. A corresponding longitudinal section, parallel with the circumference. *a*, The dotted woody tissue; the lower ends of the two cells to which the letters are appended are divided lengthwise, so as to show the irregularly thickened calibre; the others are mostly entire, showing the dots: in the cross-section the secondary deposit is seen to form indistinct layers, and some of the dots to form canals of lateral communication. *b*, Dotted ducts: the middle one in the longitudinal section is obliquely jointed. *c*, Medullary ray.

FIG. 33. Portion of four cells of the woody tissue, with both transverse and longitudinal section, highly magnified, showing the canals or deep pits in the thickened walls, and their apposition in adjoining cells: on the cross-section the layers of deposit are more plainly visible.

upon what are called *dotted ducts*; as in Fig. 32, *b*, and Fig. 56, 57. All markings of this kind are thin spots, which, for some reason, have not partaken in the general thickening of the wall. Although they are not primarily pores or real perforations, yet they often become so with age, by the destruction of the thin primary membrane, after the cell has lost its vitality. Fig. 32 shows these dots on the wood-cells and the ducts of the Plane-tree. And Fig. 33, representing some of the wood-cells more highly magnified, explains their real nature, namely, as deep pits in the thick wall. It will be seen that the pits of contiguous cells exactly correspond; showing that there is nothing accidental in the origin or the arrangement of these markings. They are manifestly designed for maintaining communication between contiguous cells, and for the ready conveyance of the sap from cell to cell, notwithstanding the thickening of their walls. Of similar nature, although of greater size, are the so-called



46. Discs or Circular Markings of Coniferous Wood (Fig. 34-37). These are of universal occurrence in the wood of Pines, Firs, and all that family of Coniferous trees; and something very like them, if not the same, occurs in the Winter's-Bark tree (as long ago shown by Mr. Brown), the Star-Anise, and even in the Magnolia, and other aromatic trees. They may readily be seen in a thin Pine shaving, taken parallel with the silver-grain: for in the Pine family they are nearly all found on the lateral walls of the cells, few or none being visible on the sides which look towards the bark or towards the

FIG. 34. Piece of a Pine shaving, magnified, to show the discs or thin spots which appear on the cells of all Coniferous wood. 35. A separate cell of the above, more strongly magnified.

FIG. 36. A small portion of five cells of White-Pine wood magnified; seen both in transverse and longitudinal section. *a, a*, discs, in transverse section; *b, b*, discs as looked down upon in longitudinal view.

FIG. 37. A highly magnified transverse section of one complete wood-cell, connected with adjacent cells, and of a disc (*a*): after Mohl.

pith; while the smaller dots, of the ordinary kind, as on the wood-cells of the Plane-tree (Fig. 32), are most abundant on the sides that look towards the centre and the circumference of the trunk. The nature of these disc-like markings is plainly revealed in the accompanying microscopical dissections of White-Pine wood (Fig. 36, 37). They are thin places, which have not received the thickening deposit that has lined all the rest of the calibre, or have received it in a lesser degree. Those of contiguous wood-cells always exactly correspond, just as do the smaller dots or pits of ordinary wood; and the two cell-membranes separate from each other, each being somewhat curved inward, thus leaving a lenticular space between them, like that between two watch-glasses put together by their edges.

47. **Bands, Rings, or Spiral Markings.** These are mostly definite portions of the wall more thickened than the rest; as is shown by the spiral vessel, where the secondary formation is restricted to a delicate thread, capable of being unwound (60), and particularly by the remarkably thick plate which winds around in the cells of certain Cacti, like a spiral staircase (Fig. 42, 43). The accompanying figures illustrate various forms of banded, reticulated, or spiral markings.



48. When the primitive walls of such banded cells remain very thin and delicate, they are apt to become obliterated at maturity, leaving the firmer fibrous markings as separate threads. This

FIG. 38. A cell of the pith of Elder, marked with oblong dots, which are thin places.

FIG. 39. Cells of the leaf of Sphagnum, or Peat-Moss, marked with a spiral fibre.

FIG. 40-43. Spirally banded cells from species of Cactus, after Schleiden.

FIG. 44. Hairs from the seed-coat of *Dipteracanthus strepens*; one with a spiral band, the other with a set of rings developed on the inner surface of the tube.

FIG. 45. Tissue from the lining of the anther of *Cobaea scandens*; where, the delicate walls of the cells being soon obliterated, nothing but the fibrous bands with which they were marked remain.

occurs in the tissue that lines the walls of the anther; and in this way the spirally marked tubes (called *Elaters*) which occur in the spore-cases of the Hepatic Mosses or Liverworts are converted into elastic spiral threads. Of a similar nature are the

49. *Gelatinous Coils*, or soft spiral threads, such as occur in the hairs or projecting cells which invest the coats of many seeds or seed-like fruits, and which when moistened often uncoil and are projected from the bursting cell in a striking manner. When water is applied, this is absorbed by endosmosis (40), the gelatinous threads swell, burst the cell-membrane, and gush out in the form of uncoiling mucilaginous fibres or bands. Good examples of the kind are furnished by the seeds of *Collomia* and *Gilia*, and by hairs or papillae on the seed-like fruits of numerous species of *Senecio* and the allied genera. Those of *Crocidium* project a thick, mucilaginous, twisted band, in place of a thread. They may subserve a useful purpose in fixing light seeds to the ground where they lodge, by means of the moisture of the first shower they receive.

SECT. III. OF THE KINDS OR TRANSFORMATIONS OF CELLULAR TISSUE; VIZ. WOODY TISSUE, DUCTS, ETC.

50. THE statements of the preceding section apply in general to the cells of which all plants are composed, irrespective of the manifold forms they may assume, and of some peculiar transformations they may undergo. Some of these should now be specified; as they give rise to kinds of tissue so unlike the ordinary cellular, in outward appearance at least, that they have always been distinguished by special names. We allude particularly to *Woody Tissue* or *Woody Fibre*, and *Vascular Tissue* or *Vessels*, of various forms. These, although formerly regarded as of independent origin, are now known to be mere modifications of one common type, the cell, and are produced in the same mode as ordinary cells. So all the statements of the foregoing section, in respect to the formation, multiplication, and growth of cells, are equally applicable to these also. Some kinds differ from ordinary cells in shape alone; others result from their combination or confluence. This is shown in two ways: first, by noting the intermediate gradations which may be found between every particular sort; and secondly, by watching their development and tracing them directly from their earliest condition, as

ordinary cells, to the peculiar forms they soon assume. In enumerating the kinds of vegetable tissue, we commence with cellular tissue strictly so called, or

51. *Parenchyma*. This is the distinctive name for ordinary membranous cellular tissue in general, such as that which forms the pith of stems and their outer bark. In the most restricted application, it belongs to such tissue when composed of angular or polyhedral cells (as in Fig. 1-3, 9, &c.); the name of *Merenchyma* having been proposed for the looser tissues (as in Fig. 7, and in the pulp of leaves and fruits generally), formed of rounded or ellipsoidal cells, that is, where they do not mutually impress each other into plane faces. But this distinction vanishes in the numberless intermediate states; and the name of *Parenchyma* is applied to both. That in which the walls touch each other, more or less, and leave intervening spaces where the ends or sides are rounded off, is termed by Schleiden *incomplete parenchyma*; and that in which the cells are in perfect contact on every side, *complete parenchyma*. The latter is *regular*, when the cells are dodecahedral or cubical; *elongated* or *prismatic*, when extended longitudinally; and *tabular*, when cubical cells are much flattened; one kind of which, called the *muriform*, because the laterally compressed cells appear in the magnified section like courses of bricks in a wall, is seen in the silver-grain of wood (Fig. 192).

52. *Prosenchyma* is the general name for tissues formed of elongated cells, especially those with pointed or oblique extremities. Every gradation may be traced between this and parenchyma. As to length, such cells vary from *fusiform*, or spindle-shaped, only three or four times longer than broad, to *tubular*, and to tubes so long and narrow that they are commonly called fibres. The most characteristic form of prosenchyma is

53. *Woody Tissue*. (*Pleurenchyma* of Meyer and Lindley. *Woody Fibre* of the older authors.) Wood, which makes up so large a part of trees



FIG. 46. Some wood-cells of the Plane-tree or Buttonwood, highly magnified: a, thin spots in the walls, looking like holes; on the right-hand side, where the walls are cut through, these (b) are seen in profile.

and shrubs, and some part of almost all ordinary herbaceous plants, is wanting in Mosses and plants of still lower grades, such as Lichens, Sea-weeds, and Fungi. That is, in the latter there is no formation corresponding to the wood of higher plants, although many of them exhibit, at least in certain parts, cells more or less elongated, or even drawn out into tubes or hollow fibres of greater length and tenuity than are those of ordinary wood; such, for instance, as the interlaced fibrous tissue of Lichens (Fig. 25). Nor, on the other hand, does the proper wood of trees (except in the Pine family) consist entirely of what is named woody tissue, but has some other sorts variously intermingled with it. Indeed, there are some trees whose wood is almost entirely composed of true parenchyma, or of large dotted cells; while in stone-fruits, and many like cases, common parenchymatous cells acquire by internal deposit (41) a ligneous consistence, and even greater hardness than ordinary wood (39). Nevertheless, the principal and characteristic component of wood in general is thick-walled prosenchyma. So that this takes the name of woody tissue even in the bark and leaves, as well as in the trunk. Fig. 32 represents some of the various elements of the wood of the Plane-tree. And Fig. 46 exhibits three or four wood-cells from the same tree, more highly magnified; the two right-hand ones cut through lengthwise, and one of these, at the upper end, with a piece of another, also cut across, to show the thickness of the walls.

54. This and the following figures likewise show how the wood-cells are as it were spliced together, overlapping one another by their tapering ends. Forming wood consists of oblong or prismatic cells, with their ends nearly square or merely oblique: as these young cells lengthen, the ends become more oblique, and push by each other, or become wedged together. The wood-cells represented in Fig. 46 are about $\frac{1}{2000}$ of an inch in diameter. Those of our Linden or Bass-wood (a few of which are shown in Fig. 50, 51) are rather larger, but not more than $\frac{1}{1500}$ of an inch in diameter.* Their size varies in different plants almost as much as ordinary cells do, but they are usually much smaller than parenchyma, especially in herbaceous plants. Perhaps the largest are found in the Pine family, where they are of a peculiar sort, and are often as much

* Lindley states that the woody tubes of the Linden are as much as $\frac{1}{150}$ of an inch in diameter; but I find none of anything like this size.

as $\frac{1}{100}$ or $\frac{1}{200}$ of an inch in diameter. The density or closeness of grain in wood, however, does not depend so much on the fineness of the wood-cells as upon the thickness of their walls. This is much greater in proportion to their diameter than in ordinary parenchyma, and, with their slenderness, and their very compact arrangement into threads or masses which run lengthwise through the stem, conspires to give the toughness and strength which characterize those parts in which this tissue abounds. In old wood of the harder kinds, the walls of the cells become so thick as almost to obliterate the calibre (Fig. 198). The thickening is generally uniform, giving rise to no markings except the pits, or small thin spots, already described (45), which appear like pores. These are of very general occurrence, and are readily seen in the wood of the Plane-tree (Fig. 32, a, 46). Markings of this kind are most conspicuous in the *Disc-bearing Woody Tissue* (*Glandular Woody Tissue* of Lindley) of the Pine Family, the nature of which has just been explained (46). On account of their markings and their unusual size, and because in the Pine family they make up the wood without any admixture of ducts, these peculiar wood-cells have been thought to be rather a form of vascular tissue. But in the Star-Anise much the same kind of marking is found on undoubtedly genuine woody tissue (Fig. 47). In the Yew, on the other hand, where the discs are few, delicate spiral markings appear (Fig. 48), showing a transition between the proper woody and the vascular tissues; as is seen by comparing the figure with that of a spirally marked duct of Bass-wood, Fig. 50, a. Here the thickening deposit is in two successive and dissimilar layers; the first, with circular vacuities, forming the discs, while the second or innermost bears the spiral markings.

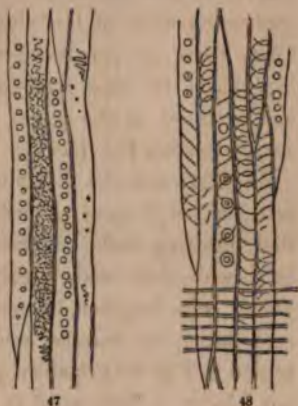


FIG. 47. Magnified woody tissue of *Illicium Floridanum* (longitudinal view), marked with large dots, like the discs on the wood-cells of the Pine family.

FIG. 48. Magnified woody tissue from the American Yew (longitudinal view), some cells showing delicate spiral lines only; some showing the disc-like markings or dots of ordinary Conifers; and others with both kinds of markings. Across the base is seen a portion of a medullary ray.

55. Bast Tissue, or *Woody Tissue of the Liber*. The bast or bass, fibrous inner bark, or liber, as it is variously termed, of those plants



that have a true bark separable from the wood of the stem, usually consists of or contains much longer, very thick-sided, and tougher, but more soft and flexible cells, than those of the wood itself. These properties are "probably given them that they may possess the strength, combined with flexibility, which their position near the circumference of a branch renders necessary." These especially adapt them to the useful purposes they so largely subserve for clothing and cordage. The textile fibres of flax, hemp, &c. are all derived from this woody tissue of the bark, separated from the brittle cells of the wood itself, and freed from the surrounding thin-sided parenchyma by maceration (which soon decomposes the latter) and by mechanical means.* The length of bast-cells as compared with wood-cells is exemplified in the accompanying figures of the two, from our Basswood (Fig. 49-51). The difference in the thickness

of the walls in this case is also great; the cells of the soft wood having rather thin walls even when old (Fig. 52), while those of the

* *Cotton* differs from linen in many respects, and is of a very different origin. It consists of hairs, or long tubular cells, growing on the seeds of the plant. These have very thin walls, which collapse so that the tube flattens, and then twists spirally, which gives them a peculiar adaptation to be spun, or drawn out together by torsion into a thread, contiguous fibres thus moderately clinging to each other as they are drawn out. But they have not such thick and tough walls as liber-cells; so a cotton fabric is not so heavy nor so durable as linen.

FIG. 49. One bast-cell, and part of another, from the bark of American Basswood. 50. Some woody tissue from the wood of the same, with, *a*, upper end of a spirally-marked duct. 51. A separate cell from the wood. All magnified to the same degree.

FIG. 52. Transverse section of some wood-cells of the Basswood, highly magnified. 53. Similar section of some bast-cells from the bark of the same tree, equally magnified.

FIG. 54, 55. Ends of bast-cells from the bark of the Leather-wood (*Dreca palustris*), magnified.

bast (Fig. 53) are so extremely thick-walled as almost to obliterate the cavity. The disproportion in length is still greater in our Leather-wood, which has a bark of extraordinary toughness, used for thongs, while the wood is very brittle and tender. Its capillary bast-cells measure from an eighth to a sixth of an inch in length, with an average diameter of $\frac{1}{8000}$ of an inch (so that, if the whole length of a cell, magnified as in Fig. 54, 55, were given, the figure would be from a foot to a foot and a half in length); while those of the wood itself are only the hundredth of an inch long. Among the bast-cells are found the longest cells which occur in any tissue. Still the individual cells are by no means absolutely so long as they are supposed, and have sometimes been stated, to be. Few are of such length as those of the Leather-wood, above mentioned. According to Mohl (*Bot. Zeit.* 1855, p. 876) there are few plants in which they exceed the twelfth of an inch; but he has found them an inch long in Flax and in our common Milkweed (*Asclepias Cornuti*), and somewhat longer in the Nettle.

56. Woody tissue runs lengthwise through the stem, root, or other organ; hence it is sometimes designated as *Longitudinal Tissue*, the *Vertical* or *Longitudinal System* of the stem, &c. It shares this name, however, with some other forms of tissue which accompany it, particularly in the wood. The cells which compose it agree in exhibiting markings of some kind on their walls, and in being larger than those of woody tissue: they are all more or less tubular, or conspire to form tubes of considerable length, and hence they have all been combined, in a general way, under the name of

57. *Vascular Tissue* or *Vessels*. Not to be misled by the name, it should be remembered that these so-called *vessels* are mere modifications of cellular tissue, and are wholly unlike the veins and arteries of animals. It is much better to call them *ducts*, a name appropriate to their nature and office, and leading to no false inferences. Their true nature is most readily shown in the largest and most conspicuous kind, one which often exhibits unequivocal indications of its cellular origin, viz.

58. *Dotted Ducts*, called also *Pitted* or *Vasiform Tissue*, *Bothrenchyma*, &c. (Fig. 56, 57). They have likewise been termed *Porous Cells* or *Porous Vessels*; but the numerous dots that characterize them are places which have not been thickened in the manner already explained (41, 44), and not perforations, except in old cells, where the primary membrane may be obliterated. Sometimes they

are continuous tubes of considerable length (Fig. 57); but occasionally they exhibit cross-lines at certain intervals, plainly showing that they are made up of a row of cells placed end to end, and becoming a tube by the obliteration of the intervening partitions (Fig. 56). In Fig. 32 some dotted ducts (one of them exhibiting oblique partitions or ends) are shown in place among the woody tissue. It is in the wood that they commonly abound. Being of greater calibre than any other cells or vessels found there, they form the pores so conspicuous to the naked eye on the cross-section of many kinds of wood, such as of Oak, Chestnut, and Mahogany, as well as the lines or channels



seen on the longitudinal section. Their size, compared with that of the wood-cells in the wood of the Plane-tree, is shown both in longitudinal and transverse section, in Fig. 31, 32.

59. *Scalariform Ducts* (Fig. 58, 59), differ from dotted ducts only in the form of the markings, the thin spots being transversely elongated instead of circular, and appearing like cross-bars, which have been likened to the rounds of a ladder, whence the name. This is the more striking when the ducts are prismatic (by mutual pressure) and the cross-bars occupy nearly the whole length of each side, as in Fig. 58. Ducts of this sort abound in the stems or stalks of Ferns. The markings are often spiral in their arrangement; as is shown in Fig. 59, by the way the duct tears into a band. Ducts of this and of the foregoing sort, where the markings are thin places, have been named by Morren and Lindley *Bothrenchyma*, meaning *pitted tissue*.



60. *Reticulated, Annular, and Spiral Ducts* (Fig. 60–65), on the other hand (called *Tracheæ*, from their resemblance to the windpipe, or rather to the tracheæ or air-tubes of insects), have been distinguished by Morren and Lindley under the general name of *Trachenchyma*. In these the markings, at least in most cases, are thicker

- FIG. 56. Portion of a dotted duct from the Vine, evidently made up of a series of short cells.
 FIG. 57. Part of a smaller dotted duct, showing no appearance of such composition.
 FIG. 58. Scalariform ducts of a Fern, rendered prismatic by mutual pressure.
 FIG. 59. Similar duct of a Fern, torn into a spiral band.

places than the rest of the wall. They are elongated cells, or tubes formed by the confluence of several cells into one, with the delicate walls strengthened by the deposition on their inner surface of additional material, in the form of bands, sometimes branching and forming network (the *Reticulated duct*), as in the middle of Fig. 60, or of rings (the *Annular duct*), as in the middle of Fig. 61, or of a continuous spiral thread (Fig. 62, 63), or a number of such threads (Fig. 64), thus forming the

Spiral duct or *Spiral vessel*. The coiled thread has been generally thought to be solid. But Trécul, in a memoir already referred to (42, note), insists that it is hollow, and it really appears to be so in the thick threads or bands of certain cells in the wood of several



sorts of Cactus, such as are shown in Fig. 40 - 43, which are well adapted for the investigation of this point. In the true *Spiral Vessel* the fibre is so strong and tough, in comparison with the delicate membrane on which it is deposited, that it may be torn out and uncoiled when the vessel is pulled asunder, the cell-wall being destroyed in the operation. This is seen by breaking almost any young shoot or leafstalk, or the leaf of an *Amaryllis*, and gently separating the broken ends; when the uncoiled threads appear to the naked

FIG. 60. A portion of a duct from the leafstalk of Celery; the lower part *annular*; the middle *reticulated*, and the thread at the upper part broken up into short pieces.

FIG. 61. Duct from the Wild Balsam or Jewel-weed; the coils of the thread distant; a portion forming separate rings.

FIG. 62. A simple spiral vessel, torn across, with the thread uncoiling.

FIG. 63. Two such vessels joined at their pointed extremities.

FIG. 64. A compound spiral vessel, partly uncoiled, from the Banana.

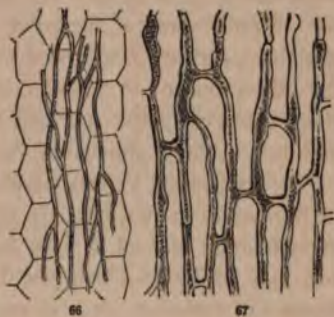
FIG. 65. A bundle of spiral ducts from the stem of Prince's Feather (*Polygonum orientale*), magnified: *a*, one composed of short cells and with the fibre closely coiled: the next, *b*, is composed of much longer joints, and has a very loose coil: *c* is short-jointed, and the fibre of the loose coil is occasionally forked: *d* and *e* show no appearance of joints or partitions, and the turns of the spiral fibre are still more remote.

eye like a fine cobweb. In stems furnished with pith, the spiral vessels usually occupy a circle immediately around it. They occur also in the veins of the leaves, and in all parts which are modifications of leaves. More commonly the coil is formed of a single fibre, as in Fig. 62, 63: it rarely consists of two fibres; but not uncommonly of a considerable number, forming a band, as in Fig. 64. Spiral vessels of the latter kind are to be found in an *Asparagus* shoot, and are finely seen in the stems of the *Banana*. From the *Musa textilis* of Manilla, of the same genus as the *Banana*, these cobwebby fibres are said to be extracted in large quantities, and used in the production of the most delicate of textile fabrics.

61. True spiral vessels, capable of uncoiling, occur in all plants of the higher grades, but only in particular parts. Reticulated and annular ducts abound in most herbaceous stems; and every transition may be detected between the various kinds. Fig. 65 shows a number of variations, such as may be seen at one view in the stem of a *Polygonum*. Some have the fibre closely coiled; in others the turns are distant. Some are simple tubes, and apparently formed of a single elongated cell: others show cross partitions, or vestiges of them, and so are made up of a row of cells; and if these be compared with Fig. 39–43, &c., it will plainly appear that ducts of all sorts are only a modification of ordinary cells. Even the longest are of no great length; very rarely are they above half an inch long; and they terminate by closed ends, like all other cells; the termination being either abrupt or more commonly conical or obtusely pointed. In young parts the ducts, like other cells, contain liquid, the ordinary juices of the plant: in older stems they are filled with air, except when the whole tissue is gorged with sap, which then finds its way into these also.

62. *Interlaced Fibrilliform Tissue*. This is quite as distinct from ordinary cellular tissue, and as worthy of a special name, as any of the kinds already described. It is the more worthy of notice, from its near resemblance to some forms of animal tissue. It consists of very long, much attenuated, simple or branching, fibre-like cells, or strings of cells, inextricably entangled or interwoven without order, so as to make up a loose, fibrous tissue. It is principally met with in *Fungi*, *Moulds*, &c., where the cells are extremely soft and destructible; and in *Lichens* (Fig. 25), where it is dry and much firmer. A remaining and a very ambiguous element of vegetable fabric is

63. Laticiferous Tissue. (*Vessels of the Latex or Milky Juice. Cinenchyma* of Morren and Lindley.) This consists of long and irregular branching tubes or passages, lying in no definite position with respect to other tissue, and when young of such extreme tenuity (their average diameter being less than the fourteen-hundredth of an inch) and of such transparency that they are hardly visible, even under powerful microscopes, except by particular manipulation. But their older trunks are larger and more evident, when gorged with the milky or other special juices which it is their office to contain, and when their sides are thickened by the deposition of such matters.



Another peculiarity is, that they *anastomose* or *inosculate*, forming a sort of network by the union of their branches, so that they freely communicate with each other. In this respect, as well probably as in the mode of their formation, they resemble the veins of animals. But their branches do not proceed from larger trunks, and in turn divide into smaller branchlets. They merely fork and inosculate here and there, the branches being commonly as large as the trunk before division. The articulations which they often present (as in the upper part of Fig. 67) would seem to prove that they are formed by the confluence of cylindrical cells. It is altogether most probable, however, that they are not composed of cells at all; but are, at first, mere passages in the intercellular spaces, which in time are bounded by walls formed by deposition from the contained fluid. Schultz, who discovered these peculiar vessels and gave to them their present name, describes a regular circulation of the juice they contain; which would make them still more analogous to the vessels or veins of animals. But this has been shown to have no real existence. There is merely a mechanical flow from any part under pressure, or towards a place from which the latex is escaping, as from a wound. Laticiferous vessels occur in the bark, especially in the liber, in the leafstalks, and in the leaves, especially of those plants which have a milky juice.

FIG. 66. Vessels of the latex, ramifying among cellular tissue, in the Dandelion; and 67, older and larger vessels from the same plant; all highly magnified.

64. All the different kinds of tissue that enter into the composition of the plant have now been described, and all (excepting the doubtful latex-vessels) referred to the cell as their original. Every plant, or each organ, consists at first of one or more cells of proper cellular tissue. In many of the simpler vegetables, the cells multiply in this primitive form solely; and the fully developed plant consists of *parenchyma* alone. But in all plants of the higher grades, some of them early assume the forms of wood-cells and of ducts. These modified cells always lie vertically in, or conspire to form, bundles or cords that run lengthwise through, the stem or other organ they occur in. They are associated with each other, and together make up the woody parts, as in the wood proper, in the liber or inner bark, and in the fibrous framework of the leaves. Although the various kinds exhibit transitions through every manner of intermediate forms, the whole, taken together, compose tissues which are almost always manifestly different from the *parenchyma* in which they are imbedded. It is convenient, therefore, to give them a general name, and to denominate them, from their position, the *Vertical* or *Longitudinal System*, or, from their nature, the *Fibro-vascular* or *Woody System*; in contradistinction to the *Horizontal* or common *Cellular System* of the plant, consisting of *parenchyma* alone.

65. *Intercellular System.* The only exception to the statement that all the vegetable tissues are formed of cells, is that of the so-called vessels of the latex, which, according to the view now best supported, are a secondary formation, resulting from the transudation of peculiar assimilated matters into the interspaces between the cells; and are therefore rather to be classed with other receptacles, canals, or intervals that are found among or between the cells. Some of these are accidental, or at least are irregular and indefinite: such are the *INTERCELLULAR SPACES* or *PASSAGES*, left when the cells are not in contact throughout. Of the same character are the larger and irregular spaces in the lower stratum of the tissue of most leaves (Fig. 7 and Fig. 221), and which form irregular winding passages through which the air, admitted through the stomates (70), freely circulates.

66. *Air-Passages*, however, are not always so irregular. The stalks, and often the foliage also, of aquatic and marsh plants generally abound with regular air-channels, of much greater diameter than the cells of the tissue. These air-passages are symmetrically ar-

rugged, and are as elaborately constructed as any proper organ can be. They are built up of cells in a manner which may be compared to a stack of flues or chimneys built of brick: they are constructed upon a uniform plan in each species, and are evidently essential parts; plants which grow in water requiring a full supply of air in their interior. Fig. 68 shows some of these air-passages in the flower-stalk of *Calla Æthiopica*.



67. **Receptacles of Special Secretions.** These arise from the exudation of the proper juices of the cells into intercellular passages, which are distended by the accumulation; or from the obliteration of contiguous cells, so as to form cavities of considerable size. Such are the turpentine-canals of the Pines, &c.; the oil-cells of the fruit of the Umbelliferae, and those in the rind of the orange and lemon; the latex-canals in Sumach, &c. *Internal Glands*, such as those which form the translucent dots in the leaves of the Orange and Myrtle, are little clusters of cells, filled with essential oil.

68. **Epidermal System.** In most plants, except of the lowest grades, and those which grow under water, the superficial layer of cells is different from the rest, and forms

69. **The Epidermis**, or skin of the plant. This consists of one or more layers of empty thick-walled cells, cohering so as to form a firm and close membrane, which may be detached from the subjacent tissue. It covers all parts of the plant which are directly exposed to the air, except the stigma. Its structure and office will be described in the chapter on the Leaves. The epidermis forms a complete and continuous covering, except that in certain parts, especially on the lower surface of the leaves, it is perforated by a multitude of small openings, called

FIG. 68. A magnified slice across part of the flower-stalk of *Calla Æthiopica* of our green-houses, showing the large air-passages, built up of cells; nearly in the centre, a bundle of woody tissue is seen in cross-section.

70. *Stomates (Stomata) or Breathing-Pores.* These have a peculiar structure, the opening being guarded usually by a pair of thin-walled cells, so arranged as to close or open according to circumstances. They will also be illustrated in the chapter on the Leaves, to which they more particularly belong.

71. *Hairs* are external prolongations of cells of the epidermis, consisting either of single elongated cells, or of several cells placed end to end, or of various combinations of such cells. They are simple or branched, single or clustered (stellate, &c.), and exhibit the greatest variety of forms. In what are called *Glandular Hairs*, or *Stalked Glands*, the upper cell or cluster of cells has a peculiar structure, and elaborates peculiar (usually odorous) products, such as the fragrant volatile oil of the Sweetbrier.

72. *Glands.* This name is applied to any secreting apparatus, and especially to superficial appendages of the epidermis which elaborate odorous or other products.

73. *Stings*, or *Stinging Hairs*, such as those of the Nettle, generally consist of a rigid and pointed cell, borne on an expanded base, or gland, which secretes an irritating fluid.

74. *Bristles (Setæ)* are rigid, thick-walled hairs, usually of a single cell. But the name is likewise given to any similar bodies, of whatever nature.

75. *Prickles* are larger and indurated, sharp-pointed processes of the epidermis or the bark (but not of the wood); such as those of the Rose and Blackberry.

76. *Scurf*, or *Lepidote, Scale-like Hairs*, are flattened, star-like clusters of cells, united more or less into a sort of scale, which is fixed by its centre to the epidermis. They are well shown in the Oleaster, Shepherdia, and most silvery leaves like theirs. Our species of *Vesicaria* exhibit beautiful gradations between these and star-shaped (*stellate*) hairs.

SECT. IV. OF THE CONTENTS OR CELLS.

77. *THESE* comprise all the products of plants, and also the materials plants take in from which these products are elaborated. To treat of them fully would anticipate the topics which belong to the chapter on Nutrition. Some of the contents of cells, however, have already been mentioned, in the account of their production and

growth (27-40): others require a brief notice here, especially two solid products which are of nearly universal occurrence and of great importance in the vegetable economy, namely, *Chlorophyll* and *Starch*.

78. The same cells contain liquids, solids, and air, at different ages. Growing and vitally active cells are filled with liquid (at least while vital operations are carried on), namely, with water charged more or less with nutritive assimilated matters, the prepared materials of growth (11, 27). Any air they may contain at this period is, for the most part, held in solution. Completed cells may still be filled with liquid, or with air, or with solid matter only. The liquid contents of the vegetable tissues, of whatever nature or complexity, are generally spoken of under the common and somewhat vague name of

79. *Sap*. In employing this name we must distinguish, first, *CRUDE SAP*; the liquid which is imbibed by the roots and carried upwards through the stem. This is water, impregnated with certain gaseous matters derived from the air, and with a minute portion of earthy matter dissolved from the soil. It is therefore inorganic (12). But, as it enters the roots and traverses the cells in its ascent, it mingles with the liquid or soluble assimilated matters which these contain, so that unmixed crude sap is never met with in the plant. On reaching the leaves, a part of the inorganic materials of the ascending sap are transformed, under the influence of light, into organizable or assimilated matter; and the liquid, thus charged with the prepared materials of growth, is now *ELABORATED SAP*. The nutritive matter of the elaborated sap is of two general kinds: 1. The *ternary*, which consists of only the three elements, carbon, hydrogen, and oxygen; and 2. The *quaternary*, which consists of four elements, viz. of nitrogen in addition to those just mentioned. *Sugar* and *dextrine*, or dissolved starch, are representatives of the first class; and these have nearly the same chemical composition as cellulose or cell-membrane. *Protoplasm* or *proteine* represents the second class (27).

80. *Sugar* (of which there are two distinct kinds, *Cane* and *Grape Sugar*) is the most soluble form of ternary organizable matter. Though sometimes crystallized as an excretion in the nectaries of flowers, yet in the plant it exists only in solution. It abounds in growing parts, in many stems just before flowering, as those of the Sugar-cane, Maize, Maple, &c., in pulpy fruits, and in seeds when

they germinate; and is the appropriate prepared material for the plant's nourishment and growth. *Dextrine* is a substance intermediate in nature between sugar and starch.

81. **Starch** (*Farina, Fecula*) is one of the most important and universal of the contents of cells, in which it is often accumulated in great quantity, so as to fill them completely (Fig. 70); as in

farinaceous roots, seeds, &c. It occurs in the parenchyma of almost every part of the plant, excepting the epi-



dermis: but while chlorophyll is nearly restricted to the superficial parts, directly exposed to the light, starch is most abundant in internal or subterranean parts, concealed from the light, as in roots and tubers, the pith of stems, and seeds. Starch consists of transparent oval or rounded grains, sometimes becoming angular by mutual pressure, as in rice. The size of the grains varies extremely in different plants, and even in the same cell; as in the potato, where the larger grains measure from $\frac{1}{800}$ to $\frac{1}{500}$ of an inch in their larger diameter, but the smallest only $\frac{1}{4000}$ of an inch. In wheat-flour the larger grains are $\frac{1}{800}$ to $\frac{1}{500}$ of an inch in diameter. And the largest starch-grains known are $\frac{1}{240}$ of an inch long. Indeed, from their formation, we might expect that their bulk would vary considerably. The mode of their formation is indicated by the peculiar markings, by which most starch-grains may be recognized; namely, by the dot or darker point which is seen commonly near one end of the grain, and the fine concentric lines drawn around it. These are best seen in starch from the potato, one of the most characteristic forms and easiest to be examined, under a magnifying power of from 250 to 500 diameters (Fig. 69). The chemical composition of starch is exactly the same as that of cellulose (27); and the grains are solid throughout, but their interior usually softer or more gelatinous. The lines evidently show that starch-grains consist of concentric layers, of different density, successively deposited on an

FIG. 69. Two cells of a potato, with some contained starch-grains, highly magnified; one of the cells contains a few cubical crystals also.

FIG. 70. A minute portion of Indian meal, strongly magnified; the cells absolutely filled with grains of starch.

original nucleus. The layers are commonly much thicker on one side than the other, so that the dot or nucleus, which all the lines surround, becomes very eccentric. Starch-grains lie loose in the cell where they are formed, and are usually separate and simple. But occasionally two or more small grains are combined by new layers into one, and in some plants they are regularly united into a cluster or compound grain, as in West-India Arrowroot, the corms of Colchicum and Arum, and the rootstocks of the Water-Lily (*Nymphaea*) and Water-Shield (*Brasenia*). In the latter the grains are oblong or club-shaped, and remarkably large. Starch-grains are nearly uniform in the same plant or organ, and of very different appearance in different plants: so that the smallest quantity of starch from the potato, wheat, rice, maize, arrow-root, &c., may at once be distinguished under the microscope. In this way adulterations of arrow-root, &c. may be detected. The outer layers of large and well-developed starch-grains (such as those of the potato) are denser than the inner: consequently, each grain is marked by a dark cross when viewed by polarized light. Starch is unaffected by cold water; but hot water is absorbed by it; the inner part of the grain softens first and swells, inflating the denser superficial portion into a large sac, which may at length burst or be dissolved. It thus forms a jelly with boiling water, but is not really soluble in it. When truly dissolved, it is no longer starch, but, by a slight change in its character, it is changed into dextrine (80). The chemical test of starch is iodine, which turns it blue.

82. Starch is the form in which nourishing matter is stored up in the plant for future use; in which respect it may be likened to the fat of animals. It is the ready-prepared material of vegetable fabric, — the same as cellulose in a particular and more soluble form, — accumulated in the cells of certain parts as a provision for future growth. When about to be used, the grains are dissolved in the plant at the natural temperature; that is, the starch is converted into dextrine, which differs chiefly in being soluble in cold water, and this changes into sugar, which is still more soluble; and thus a sirup is formed, which the sap dilutes and conveys to the adjacent parts, or to wherever growth is going on.

83. Amyloid (of which *Bassorin*, *Salep*, and *Pectine* are apparently modifications), which in solution is *Vegetable Jelly*, is intermediate in character between starch, dextrine, and cellulose, and has nearly the properties of starch, when this has been altered by hot water. It

abounds in the almond, bean, and some other esculent seeds, in the tubers of Orchises (as Salep, &c.), and forms the principal substance of many sea-weeds, such as the Carragheen Moss (*Chondrus crispus*), from which jelly is obtained for culinary purposes. When dry, it is horny or cartilaginous, and lines the cells; when moist, it swells up, becomes gelatinous, and is capable of being perfectly diffused through cold water. We have it as an excretion in Gum Tragacanth. True gums, such as Gum Arabic, are states of nearly the same substance, and are likewise formed only as excretions.

84. **Fixed Oils** belong to the class of ternary products, but they contain little oxygen, and some of them none at all. The fatty oils take the place of starch in the seeds of many plants (as in flax-seed, walnuts, &c.), and of sugar in some fruits, such as the olive. They also occur in the herbage of most plants.

85. **Wax** is a product of nearly the same nature as the fixed oils, only it is solid at the ordinary temperature. It occurs as an excretion, particularly on the surface of leaves and fruits, forming the bloom or *glaucous* surface which repels water, and so prevents such surfaces from being wetted. It forms a thick coating on some fruits, as the bayberry. Wax also exists in all herbage, being one of the components of the green matter of plants (92).

86. **Vegetable Acids.** *Tartaric*, *Citric*, and *Malic Acids* are the principal kinds; they are found in the herbage of those plants which have a sour juice, such as Sorrel and the Grape-Vine. They are ternary products, with a larger proportion of oxygen than starch, sugar, and the like. They do not appear to play any leading part in vegetation. They seldom exist in a free state, but are combined with the alkaloids, and with the inorganic or earthy alkalies (Potash, Soda, Lime, and Magnesia), which are introduced into plants from the soil with the water imbibed by the roots. The more soluble salts thus produced are found dissolved in the sap; the more insoluble are frequently deposited in the cells, either as an incrustation of their walls, or in the form of minute crystals. When these crystals contain a vegetable acid, it is almost always *Oxalic Acid*. This is an almost universal vegetable product, and is a binary body (that is, consists of two elements only, carbon and oxygen), differing from carbonic acid in ultimate composition only in having a little more oxygen. *Hydrocyanic* or *Prussic Acid* is one of the special products peculiar to certain plants, and of very different composition, containing a large portion of nitrogen.

87. **Tannin or Tannic Acid**, which most abounds in older bark, is probably a product of the oxidation or commencing decomposition of the tissues. So, also, *Humus*, *Humic Acid*, *Ulmic Acid*, and the numerous related substances distinguished by the chemists, are products of further decomposition of vegetable tissue, rather than true products of vegetation.

88. **Essential Oils, Turpentine, Caoutchouc, &c.** These are some of the *Proper Juices* of plants, peculiar to certain plants, and occurring under a great variety of forms in different species. It is not known that they are of any account in vegetable growth or nutrition. They undergo changes on exposure to the air, and become resins, gums, &c. They are apt to be accumulated in intercellular cavities, or to be excreted from the surface of the plant. Not knowing of what use they are to the vegetable, we are inclined to regard them as of the nature of *excretions*. *Caoutchouc* exists in the form of minute globules, diffused as an emulsion in the milky juice of plants, of various families. The original *India-Rubber* of the East Indies is the milky juice of a species of Fig. That of South America, now so largely used for a great variety of purposes, comes from certain trees of the *Euphorbia* family. It equally occurs in the juice of our Milkweeds or Silkweeds. *Gutta-Percha* is a similar product of the milky juice of a Sapotaceous tree of Borneo.

89. The *quaternary* class of products (viz. those which consist of the four elements, carbon, hydrogen, oxygen, and nitrogen, 79) are of two kinds, the *special* and the *general*. The former are peculiar to certain plants; the latter are universal products of vegetation. Examples of the special kind are found in *Hydrocyanic* or *Prussic Acid*, already mentioned (86), and the

90. **Alkaloids**, such as *Morphine*, *Strychnine*, and *Quinine*. These are principally formed in the bark and the leaves. We do not know that they bear any part in vegetation, nor of what use they are to the plant. In these substances reside the most energetic properties of the vegetable, considered as to its action on the animal economy, the most powerful medicines, and the most virulent poisons. That they are of the nature of excretions may be inferred from the fact, that a plant may be poisoned by its own products, introduced into its ascending sap.

91. The principal general quaternary product of plants is *Proteine*, the nature and uses of which have already been explained (27, 79). As it exists in living cells in a liquid or gelatinous

state, it receives the name of *protoplasm*. Besides lining the walls of living cells and forming the nucleus, it is also a component of one of the most important vegetable products, viz.

92. **Chlorophyll**, or, as the name denotes, *Leaf-green*, the substance which gives the universal green color to the leaves and herbage. This is formed principally in parts exposed to the light, such as the green bark, and especially the leaves. It generally occurs in the form of minute soft granules, either separate or in clusters, which lie free in the cells (Fig. 71), or adhere loosely to their sides. In some common *Confervæ* the chlorophyll takes the form of rows of granules, or of continuous bands, often spiral in form. The exact composition of chlorophyll is still unknown. The green coloring matter makes only a small part of the bulk of the grains. It may be dissolved out by alcohol or ether, leaving a colorless mass, which, as it is turned yellow by iodine, evidently contains nitrogen. The green matter is found to consist partly of wax, and partly of a peculiar quaternary substance allied to indigo.

93. **Earthy Incrustations**. As the roots naturally take in some earthy matters, dissolved in the water they absorb from the soil, these necessarily accumulate in the cells of the plant. The siliceous and calcareous matters, being very sparingly soluble, are usually deposited on the walls of the cells as an incrusting lining, or else are incorporated into its substance along with the organic thickening deposit (41). This earthy part of vegetable fabric may be brought to view by carefully burning a piece of a leaf or any other organ, — which decomposes and drives off all the vegetable matter, — and then examining the ashes by the microscope. These are mineral matter, and when undisturbed they will be found to have copied the shape and all the minute markings of the cells, like casts. In the *Diatomaceæ*, — a family of microscopic and ambiguous plants of the simplest structure, — a great part of the thickness of the cell-wall is silex, and consequently indestructible by decay. So that the forms of these minute organisms are preserved indefinitely, after the decomposition of the organic structure; their silicious remains accumulating at the bottom of the water in which they lived, to such extent as to produce immense strata in many places, their forms and markings so perfectly preserved for ages that the species may be nearly as well characterized from these casts as from living individuals. Earthy matters also occur in the cells of plants in the form of microscopic

94. Crystals, or Raphides (Fig. 71-78). These exist in more or less abundance in almost every plant, especially in the cells of the bark and leaves, as well as in the wood and pith of herbaceous plants. In an old stem of the Old-man Cactus (*Cereus senilis*), the enormous quantity of eighty per cent of the solid matter left after the water was driven off was found to consist of these crystals. In the thin inner layers of the bark of the Locust, each cell contains a single crystal, as is shown in Fig. 75. Professor Bailey, who has devoted particular attention to this subject, computed that, in a square inch of a piece of Locust-bark, no thicker than ordinary writing-paper, there are more than a million and a half of these crystals. There is frequently a group of separate crystals in the same cell, or a conglomerate cluster, as in Fig. 76. The most common form is that of a long and narrow four-sided prism, so slender that it resembles a needle (Fig. 71-73). Such crystals were accordingly called *Raphides*, i. e. needle-shaped bodies,—a name which has been extended to include all crystals in plants, of whatever shape. When the crystals are needle-shaped, they usually occur in large numbers in each crystal-bearing cell, packed together in a bundle. These



FIG. 71. Raphides, or acicular crystals, from the stalk of the Rhubarb: three of the cells contain chlorophyll, and two of them raphides.

FIG. 72. Raphides of an Arum, contained in a large cell; and 73, the same, detached from the surrounding tissue, and discharging its contents upon the application of water.

FIG. 74. Crystals from the base of an onion, one of them a hemitrope or double.

FIG. 75. Crystals of the inner bark of the Locust.

FIG. 76. A glomerate mass of crystals from the Beet-root.

FIG. 77, 78. Crystals from the bark of Hickory. Figures 73-78, and also 69, are from sketches kindly supplied by the late Professor Bailey of West Point.

may be readily found in the stalks of the Rhubarb, the Four-o'clock, the Arum or Indian Turnip, and the Calla. In the latter plants, a crystal-bearing cell in the leaf may often be detached entire from the surrounding tissue: when moistened, it absorbs water by endosmosis, becomes distended, and may sometimes be seen to eject its crystals one by one, in a curious manner, through a minute perforation at one or both ends (Fig. 73). As to their composition, these crystals more commonly consist of oxalate of lime; but those of carbonate, sulphate, or phosphate of lime are not unfrequent.

95. *Cystolithes* are a peculiar structure composed of crystalline mineral and of vegetable matter combined, of common occurrence in the leaves of the Fig, Hop, Mulberry, and all the Nettle family, just beneath the epidermis. They are globular or club-shaped bodies, or of various other forms, usually hanging by a short stalk in an enlarged cell: their principal mass is found to be cellulose; but their surface is studded with crystalline points of carbonate of lime.

CHAPTER II.

OF THE GENERAL DEVELOPMENT AND MORPHOLOGY OF PLANTS.

96. HAVING ascertained what vegetable fabric consists of, we are prepared to consider how these organic materials, the *cells*, are combined to constitute a vegetable, what the parts or organs of plants are, how they are related to each other, and how they live, grow, and perform the work of vegetation. Viewing plants as individual beings, we may now proceed to study their *Organography* or *Morphology* (3).

97. Plants occur under the greatest diversity of forms. Some kinds are of the utmost simplicity; and many of these are so minute, that separately they are invisible to the naked eye, and become apparent only by their aggregation in vast numbers. Others are highly complex in structure, and may attain a great size, such as gigantic trees, some of which have flourished for a thousand years or more. But each plant or tree, however vast or complex it may become, commenced its existence as a single vegetable cell, by the

multiplication of which the whole fabric was built up. All our ordinary herbs and trees, however, even while in the seed, have already passed beyond this stage, and consist at this time of a mass of cells, more or less distinctly wrought into the form of a plantlet; while the germs of plants of a lower grade, at the time of their separation from the parent plant, are each no more than a single cell. Cells of this kind, destined to give rise to new individuals (i. e. for reproduction), are called SPORES. The name *spore* is from a Greek word, meaning the same as seed.

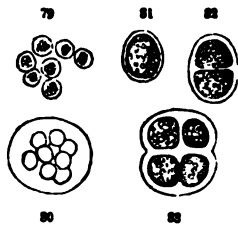
98. Plants may be distinguished, therefore, into two great *Series* or *Grades*, a lower and a higher;—the lower or simpler grade consisting of those plants which directly spring from single cells or spores; the higher grade, of those which spring from seeds.

SECT. I. PLANTS OF THE LOWER GRADE; THEIR DEVELOPMENT FROM THE CELL.

99. THIS grade includes the simplest and minutest plants, and also many which attain a great size, and exhibit no small complexity of structure, such as Tree Ferns (Fig. 100), for instance. The very lowest kinds not only begin their existence as single cells, but continue so throughout their whole growth. The most simple possible form of vegetation therefore consists of

100. *Plants of a Single Cell.* In these minims of the vegetable world, the plant is reduced to its lowest terms: the *plant* and the *cell* are here identical. The cell constitutes *an entire vegetable without organs*, imbibing its food by endosmosis (40) through its walls, assimilating this food in its interior, and converting the organizable products at first into the materials of its own enlargement or growth, and finally into new cells, which constitute its progeny. Thus we have an epitome of all that is essential in vegetation, even on the largest scale; namely, the *imbibition of inorganic materials*; their *assimilation*; their application to the growth of the individual, or *nutrition*; and the formation of new individuals, or *reproduction*. Every stream or pool of water abounds with such plants, often in great variety. Simple as these plants are, they are by no means restricted to one monotonous pattern: perhaps they present as great diversity of form as do the kinds of ordinary vegetation, although from their minuteness they are mostly invisible to the naked eye.

The admirable memoirs of Nägeli and of Braun upon One-celled Plants, and the works of Ralfs, Kützing, Thwaites, &c. upon the Desmidiaceæ and Diatomaceæ, illustrate a great variety of forms. The simplest possible case is that of



101. *Plants of a Single Globular Cell;*

that is, of a cell which grows equally in every direction, and therefore retains the original form. The microscopic plant known as giving rise to the phenomenon of *red snow* furnishes a good illustration of the kind (Fig. 79, 80): and so does a more common species, *Protococcus cruentus*,

which forms dull-crimson patches, resembling blood-stains, on the northern side of damp rocks or old walls. Each sphere is a single cell, which, quickly attaining its growth, produces (probably by division of the contents) a number of free cells in its interior. These escape by the decay of the walls of the mother-cell, grow speedily into similar cells or plants themselves, giving rise to another generation, and perish in their turn. Fig. 81 represents another and similar one-celled plant; and Fig. 82 and 83 show its mode of propagation, namely, by division of the whole living contents into two portions, and these again into two, these four globular masses soon acquiring a wall of cellulose, and becoming so many distinct cells or plants;—the whole process admirably illustrating a common mode of cell-multiplication (36). Indeed, another microscopic plant of the kind, very common in shallow pools at the beginning of spring, was taken as the readiest example of this multiplication of cells (Fig. 18–22). This propagation causes the destruction of the mother-plant in each generation, all its living contents being employed in the formation of the progeny, and its effete wall obliterated by softening or decay, and by the enlargement of the contained cells. Thus the simplest vegetation goes on, from generation to generation. The softened remains of the older cells often accumulate and form a gelatinous stratum or nidus, in which the succeeding generations are developed, and from which they doubtless derive a

FIG. 79. Several individuals of the Red-Snow Plant (*Protococcus nivalls*) magnified. 80. An individual highly magnified, showing more distinctly the new cells or spores formed within it.

FIG. 81. An individual of *Chroococcus rufescens*, after Nägeli, much magnified. 82 A more advanced individual, with the contents forming two new cells by division. 83. Another, with the contents divided into four new cells.

part of their sustenance,—just as a tufted Moss is nourished in part from the underlying bed of vegetable mould which is formed of the decayed remains of its earlier growth. Other one-celled plants enlarge in one direction more than in any other, so becoming oval or oblong, and making a transition to a somewhat higher grade of vegetation, viz.

102. *Plants of a Single Elongated Cell.* Such plants may be conceived to bear the same relation to the foregoing, that ducts (57) and wood-cells (53) do to cells of parenchyma (51). For an example we may take any species of *Oscillaria* (Fig. 84); a form of aquatic vegetation of microscopic minuteness, considered as to the size of the individuals; but these rapidly multiply in such inconceivable numbers, that, at certain seasons, they sometimes color the surface of whole lakes of a green hue, as suddenly as broad tracts of alpine or arctic snow are reddened by the Red-Snow Plant. If the transverse markings of some *Oscillarias* answer to internal partitions, then they make a transition between one-celled plants and those formed of a row of cells.—Since cells which form part of the fabric of vegetables are sometimes branched (38), we should naturally expect to find, as the next step in the development,

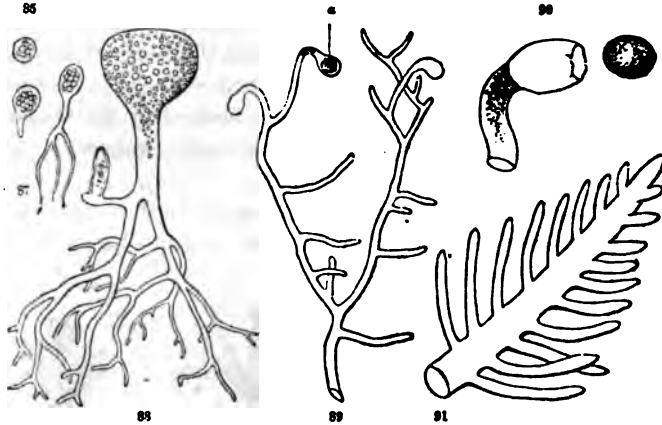


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103. *Plants of an Elongated and Branching Cell.* Good examples of the sort are furnished by the species of *Vaucheria*, which form one kind of the delicate and flossy green threads abounding in fresh waters, and known in some places by the name of *Brook-silk*. These, under the magnifying-glass, are seen to be single cells, of unbroken calibre, furnished here and there with branches (Fig. 89). The branches are protrusions, or new growing points, which shoot forth by a sort of budding, and have the power of continuous growth from the apex. In *Bryopsis* (Fig. 91), a beautiful small Sea-weed, the branches are much more numerous and regularly arranged; their cavity is continuous with that of the main stem, if we may so call it: in other words, the whole plant, which is by no means minute, consists of a single, repeatedly many-branched cell. And in *Codium*, another genus of marine Algae, we have an indefinitely

FIG. 84. Two individuals of *Oscillaria spiralis*, magnified; one with an extremity cut off.

ramified cell, intricately interlaced or compacted, and forming dense masses of considerable size and of definite shapes.



104. While in these cases the ramifications of the cell imitate, or as it were foreshadow, the stem and branches of higher organized plants, we have in *Botrydium* (Fig. 88) a cell whose ramifications resemble and perform the functions of a root. This consists of an enlarged cell, which elongates and ramifies downwards, the slender branches penetrating the loose and damp soil on which the plant grows, exactly in the manner of a subdivided root. Meanwhile, a crop of spores or rudimentary new cells is produced, by original cell-formation (29), in the liquid contents of the mother-cell: these, escaping when that decays or bursts, grow into similar plants, in the manner shown by Fig. 86, 87. The spores by which *Vaucheria* is propagated originate in a somewhat different way. When about to fructify, the apex of a branch enlarges, its green contents thicken, separate from those below, condense into a rounded mass, which acquires a coat of protoplasm (Fig. 89, *a*): the sac in which it was formed soon bursts open, and the new-born spore escapes into the water (Fig. 90). It moves about freely for some hours (678), when a coat of cellulose is formed upon its surface, converting it into a true cell, which soon

FIG. 85-87. *Botrydium Waltherii* in its development, and with new cells forming within; after Kützing: 85, the cell still spherical: 86, pointing into a tube below: 87, the tube prolonged and branched: all much magnified.

FIG. 88. *Botrydium argillaceum*, after Endlicher; the full-grown plant, magnified.

FIG. 89. *Vaucheria clavata*, enlarged: *a*, a spore formed in the enlarged apex of that branch. 90. End of the branch, more magnified, with the spore escaped from the burst apex.

FIG. 91. *Bryopsis plumosa*; summit of a stem with its branchlets, much enlarged.

grows by elongating into a thread, one end of which fixes itself to a stone or some other solid body, while the other grows first into a simple tube, and then sends off branches like its parent. In this way, a plant composed of a single cell imitates not obscurely the upward and downward growth (the root and the stem) of the more perfect plants, or when cells like these, whether simple or branched, form cross-partitions as they grow, in the manner of the *Conferva* (Fig. 15) used to illustrate this mode of cell-multiplication, they give rise to

105. **Plants of a Single Row of Cells.** Most of the thread-like green Algae (*Conferveae*), which abound in pools and brooks, are of this sort. So are the

Moulds or Mildew Fungi, of which three kinds are here represented; viz. the Bread-Mould (Fig. 92), and the Cheese-Mould (Fig. 93), which live upon dead organic matter; and



a species of *Botrytis* (Fig. 94). The latter, and other Moulds of the same or of other kinds, feed upon the juices of living plants, and even animals, where they commit great ravages. The too well-known potato-disease, for example, is probably caused by the attack of a species of *Botrytis*; a similar species has long been known as the cause of the muscardine, a fatal malady of silk-worms, and the malady which has for several years destroyed a great part of the grape-crop in Europe is caused by another parasitic plant of the same simple structure. The accompanying figures show only the perfect state of these troublesome little plants, or rather their fructification. Their vegetation consists of long and branching threads (of which a small portion only is represented at the base), which penetrate and spread widely and rapidly through the vegetable, or other body they live on, and feed upon its juices. At length they break out upon the surface, and produce countless numbers of

FIG. 92-94. Three kinds of Mould, magnified. 92. The Bread-Mould (*Mucor*, or *Ascomphora*). 93. The Cheese-Mould (*Aspergillus glaucus*). 94. *Botrytis Bassiana*, the species which attacks silk-worms, &c.

spores (97), or minute rudimentary cells, which are detached from the parent plant and serve the purpose of seeds. The spores are in some cases produced (probably by original cell-formation), in an enlarged terminal cell, as in the Bread-Mould (Fig. 92); while in other cases they are naked, and arise from cell-division, as in Fig. 93, 94.

106. Plants of this simple structure (belonging chiefly to the lower Algae and Fungi) are almost as various in form and numerous in species as are the higher kinds of vegetation. Some consist of a single jointed thread; others are excessively branched; and sometimes the branches are interlaced or compacted to form masses or strata of considerable size. Some of them present little or no distinction among the cells they consist of, each cell performing the same office as any other, and each capable of producing spores or in some way serving for reproduction; such may well be regarded as rows of one-celled plants, more or less united. But more commonly, even in the simplest vegetable forms, the work which the plant has to perform is divided, some parts serving for vegetation or nutrition, and others for reproduction, as we see is the case with the Moulds, &c. Even a one-celled plant may begin to have organs, or parts adapted to special purposes, as is well shown by *Botrydium* and *Vaucheria* (Fig. 85-90). As we ascend in the scale of vegetable life, more and more specialization will be found at every step.

107. A slight change in the way the cells multiply, namely, the formation of partitions in two directions instead of only one, introduces the next advance in vegetable development, giving rise to



108. Plants of a Single Plane or Layer of Cells. Figures 18-22 show how a plant of a single spherical cell may multiply, by repeated

FIG. 95. A piece of *Delesseria Leprieurei*, from Hudson River, of twice the natural size. 96. A portion of the whole breadth of the same, more magnified, to show the cellular structure. The cells have thick gelatinous walls; those in the middle are elongated, those towards the margins rounded. 97. A small portion still more magnified.

division, into two, four, and sixteen such plants, and so on. But if these cells had merely remained in connection as they multiplied, they would have composed one plant, consisting of a stratum of cells. This is just what we have in the Dulse or Laver (*Ulva*, &c.) and some other simple leaf-like Algae of various kinds, such, for example, as that illustrated in Fig. 95-97. When the whole body of a plant is thus expanded and leaf-like, it forms what is called a FROND.

108°. Not only Sea-weeds, but many Liverworts and Lichens, grow in this way. (In Lichens, &c., the expanded body usually takes the name of THALLUS.) In most cases, however, such plants are composed of more than one layer of cells, or of a considerable number of layers. And those of thread-like forms, resembling naked stems and branches, in all the coarser and in some very delicate kinds, are made up, like the parts of ordinary vegetables, of several thicknesses of cells; that is, they are

109. Plants of a Solid Tissue of Cells, formed by cell-multiplication through division taking place in more than two directions. Sea-weeds, Lichens, and other plants of the lowest orders, forming in this way a tissue of cells, generally exhibit either leaf-like or stem-like shapes, but seldom if ever do they present both in the same plant. They may resemble leaves, or they may resemble stem and branches, or display a variety of forms intermediate between stem and leaf. But it is only when we come to the highest tribe of Liverworts, and to the true Mosses, that the familiar *type* of ordinary vegetation is realized in

110. Plants with a Distinct Axis and Foliage; that is, with a stem which shoots upward from the soil, or whatever it is fixed to, or creeps on its surface; which grows onward from its apex, and is symmetrically clothed with distinct leaves as it advances. All these lower vegetables, of whatever form, imbibe their food through any or every part of their surface, at least of the freshly formed parts. Their roots, when they have any, are usually intended to fix the plant to the rock or soil, rather than to draw nourishment from it. The strong roots of the *Oar-weed*, *Devil's Apron* (*Laminaria*), and other large Sea-weeds of our coast, are merely hold-fasts, or cords expanding into a disc-like surface at the extremity, which by their adhesion bind these large marine vegetables firmly to the rock on which they grow. Mosses also take in their nourishment through their whole expanded surface, principally therefore by their leaves; but the stems also shoot forth from time to time delicate rootlets,

composed of slender cells which grow in a downward direction, and doubtless perform their part in absorbing moisture. A Moss, there-

fore, is like an ordinary herb in miniature, and exhibits the three general ORGANS OF VEGETATION, viz. *Root*, *Stem*, and *Leaves*.

111. Cellular and Vascular Plants.

While the Mosses emulate ordinary herbs and trees in vegetation and external appearance, they accord with the lowest kinds of plants in the simplicity of their anatomical structure. They are entirely composed of cellular tissue strictly so called, chiefly in the form of parenchyma (51); at least they have no distinct vessels or ducts (57) and no true wood in their composition. The Mosses, along with the Lichens, Algæ, Fungi, &c., were therefore denominated CELLULAR PLANTS by De Candolle. All plants of higher grade, inasmuch as vascular and woody tissues enter into their composition, when they are herbs as well as when



they form shrubs or trees, he distinguished by the general name of VASCULAR PLANTS.

112. The strength which woody tissue imparts (54) enables plants in which it abounds to attain a great size and height; while Mosses and other cellular plants are of humble size, except when they live in water, in which some of the coarser Sea-weeds do indeed acquire a prodigious length. Although true Mosses have no wood in their composition, yet the so-called Club-Mosses have. So also have the Ferns, the highest organized family of the lower grade of plants; and although these are mostly herbs, or else plants with their more or less woody stems creeping on or beneath the surface of the ground, yet in warm climates some species rise with woody trunks into tall and palm-like trees. But even these, like the hum-

FIG. 98. An individual of a Moss (*Physcomitrium pyriforme*), enlarged to about twelve times the natural size. 99. Tip of a leaf, cut across, much magnified, to show that it is made up (except the midrib) of a single layer of cells.

blest Mosses or the minutest Moulds, spring from single cells or spores (97), and not from true seeds. And the apparatus by which these spores are produced, whatever be its nature, is not a flower. Plants of the lower grade (98, 99) are therefore collectively denominated

113. Flowerless or Cryptogamous Plants. The first name expresses the fact that the organs of fructification in these plants are not of the nature of real flowers. The second name, which was introduced by Linnaeus, and is composed of two Greek words meaning "concealed fructification," refers to the obscure nature of the organs or the processes of reproduction in these plants, which have only recently come to be understood. Some account of them will be given in Chapter XII.



SECT. II. PLANTS OF THE HIGHER GRADE; THEIR DEVELOPMENT FROM THE SEED.

114. Flowering or Phanogamous Plants,* — so called in contradistinction to the Flowerless or Cryptogamous, — is the general name for the higher grade of plants, to which our ordinary herbs, shrubs, and trees belong, and which may be said to exhibit the perfected type of vegetation. The lower grade begins with plants so simple as to

* Sometimes written *Phanerogamous*. Both terms are made from the same Greek words, and signify, by a metaphorical expression, the counterpart of Cryptogamous; that is, that the essential organs of the flower are manifest or conspicuous.

FIG. 100. Sketch of a Tree Fern, *Dicksonia arborescens*, of St. Helena; after Dr. J. D. Hooker. 101. *Polypodium vulgare*, a common Fern, with its creeping stem or rootstock.

be destitute of organs; and it is only in the higher Cryptogamous plants, such as Mosses and Ferns, that the familiar organs of ordinary vegetation appear as separate parts of the plant, viz. the root, stem, and leaves. In the higher grade (i. e. in Phenogamous Plants) these three parts are well defined, and always present, in some form or other;—a few anomalous instances excepted, such



as the common Duck-weed, for example (Fig. 102).

Here stem and leaf are as it were blended, in the manner of a Liverwort, to form a flat green body, which floats on the water, exposing the upper surface like a leaf to the light, while one or more roots proceed from the lower, and a small and simple flower at length makes its appearance on some part of the margin. This is an extremely simplified state of a Phenogamous plant.

115. Ordinarily, not only are the root, stem, and foliage distinct and separate from each other, but also distinct from the apparatus for reproduction. So that the plant is composed of two kinds of organs, viz. ORGANS OF VEGETATION and ORGANS OF REPRODUCTION.

116. The Organs of Vegetation are the *Root, Stem, and Leaves* (110). These are so called because they are jointly concerned in the nutrition and growth of the plant, and in the performance of all its characteristic functions, and they are all that is so concerned. Making up as they do the entire vegetable, and repeated under varied forms throughout its whole development, they are also termed the **FUNDAMENTAL ORGANS** of plants.

117. The Organs of Reproduction in the simplest Cryptogamous plants are not distinct from those of vegetation; but in most plants, even of the lowest families, the cells for reproduction are different in appearance and in the mode of their formation from those which serve for vegetation. These reproductive cells, or *Spores*, with the apparatus for their production and protection, whatever it may be, constitute the organs of reproduction in Cryptogamous plants. In Phenogamous plants the organs of reproduction are the **FLOWER**, essentially consisting of *Stamens* and *Pistils*, and the result of their co-operation is the production of **SEED**.

118. A **Seed** is a body produced by the agency of a flower, which contains, within one or more coats or coverings, a ready-formed

plantlet in a rudimentary state. Flowerless or Cryptogamous plants spring from spores or single cells, which when they germinate multiply to produce a tissue or an aggregation of cells, that at length grows and forms a plantlet. But a seed contains a plantlet ready formed, or a germ, which is called an EMBRYO. And the history of a Flowering or Phenogamous plant naturally begins with

119. The Development of the Embryo from the Seed. The embryo varies exceedingly in size, shape, and appearance in different plants; but it is constructed upon the same general plan in all; and the development of almost any plantlet from the seed will serve to illustrate the principal laws and processes of vegetable growth. To commence with the study of the seedling is the readiest way to understand the whole vegetable structure and life.

120. The seeds of the Red or the Sugar Maple furnish good illustrations, and they are readily met with in *germination*, i. e. just developing the embryo into a plant. Also they are large enough to allow the embryo to be extracted from the seed-coats, and inspected by the naked eye, or by the aid of a common hand-glass. (Fig. 103-105.) Here

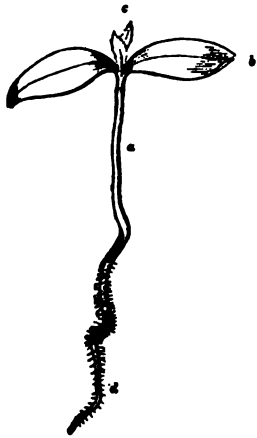
the whole contents of the seed consist of an embryo, neatly coiled up within the seed-coats. If unfolded, or, which is



better, if examined when just unfolding itself in germination, it is seen to consist of a tiny stem or axis (Fig. 104, 105, *a*), bearing a pair of small leaves on its summit. The axis is called the RADICLE, because it was supposed to be the root; though it is really the rudiment of the stem rather than of the root, and therefore were better named the *Caulicle*; but the former name is now too well established to be superseded. The two little seed-leaves (*b, b*) are technically called COTYLEDONS: and a little bud which will presently appear between them (Fig. 106, *c*), or may be discerned there in many embryos before germination (as in the Almond, Fig. 108, *a*) is named the PLUMULE. The embryo, accordingly, is a short axis or stem bearing upon one end some rudimentary leaves;

FIG. 103. Embryo of Sugar-Maple as coiled up in the seed. 104, 105. The same, just beginning to unfold and develop in germination: *a*, the radicle, or primary stem: *b, b*, the cotyledons or seed-leaves.

or, in other words, it is a primary stem crowned with a *leaf-bud*. When it grows, this stem elongates throughout its whole length, so as usually to raise the budding apex above the surface of the soil, into the light and air, where its cotyledons expand into leaves; and



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at the same time from the opposite extremity is formed the root, which grows in a downward direction, so as to penetrate more and more into the soil. The two extremities of the embryo are differently organized, are differently affected by light and air, and grow in opposite directions. The budding end invariably turns towards the light, and grows upwards into the air; the root-end turns constantly from the light, and buries itself in the dark and moist soil. These tendencies are absolute and irreversible. If the budding end happen to lie pointing downwards and the root end upwards, both will curve quite round as

they grow to assume their appropriate positions. If obstacles intervene, the root will take as nearly a downward, and the stem as nearly an upward direction, as possible. These are only the first manifestations of an inherent property, which continues, with only incidental modifications, throughout the whole growth of the plant, although, like instinct in the higher animals, it is strongest at the commencement: and it insures that each part of the plant shall be developed in the medium in which it is designed to live and act,—the root in the earth, and the stem and leaves in the air. The plantlet, therefore, possesses a kind of polarity; it is composed of two counterpart systems, namely, a *Descending Axis*, or root, and an *Ascending Axis*, or stem. The point of union or base of the two has been termed the *crown*, *neck*, or *collar*. Both the root and stem branch; but the branches are repetitions of the axis from which they spring, and obey its laws; the branches of the root tending to descend, and those of the stem to ascend.

FIG. 106. A germinating embryo of Sugar-Maple, more advanced: *a*, the radicle elongated into the first joint of stem, bearing the unfolded cotyledons or seed-leaves, *b*, and between them the plumule (*c*), or rudiments of the next pair of leaves; while from its lower extremity the root, *d*, is formed.

121. The root and the stem grow not only in opposite directions, but in a different mode. The little stem, pre-existing in the seed, grows throughout its whole length, (but most in its upper part,) so that a radicle of perhaps less than a line in length may become a stemlet two or three inches long. It is by this elongation that the seed-leaves are raised out of the soil, so as to expand in the light and air. Meanwhile a root begins to be formed at the other end of the radicle; and this lengthens by continued cell-multiplication mainly at its lower extremity, the parts once formed scarcely if at all elongating afterwards; but the growth takes place continuously at the tip alone. The primary stem, bearing the pair of seed-leaves, soon completes its development, and ceases to lengthen. Then, if not before, the plumule (Fig. 106, c) begins its growth and develops into a second stemlet on the summit of the first, bearing its pair of leaves. It lengthens in the manner its predecessor did, and carries up the second pair of leaves to some distance above the first; then from between them springs a third joint of stem, crowned with its pair of leaves (Fig. 107); and so on, building up the whole herb or tree by this succession of similar growths or joints of stem. The root, on the other hand, grows on in a downward direction continuously, is not composed of a series of joints, and bears no leaves or other organs.

122. The youngest seedling is therefore provided with all the organs of vegetation that the full-grown plant possesses; and even the embryo in the seed is already a miniature vegetable. It has a stem, from the lower end of which it strikes root in germination; it has leaves, and it has or soon forms a bud, which develops into new joints of stem bearing additional leaves, while beneath it sends its root deeper and deeper



FIG. 107. A seedling Maple which has developed two additional joints of stem, each with their pair of leaves.

into the soil. The root absorbs materials for the plant's nourishment from the soil; these are conveyed through the stem into the leaves, and there assimilated (12, 15), under the influence of the light of the sun and the air, into organic matters which serve directly for further growth, and form the fabric of new portions of stem, new leaves, and new roots, the vegetable thus increasing its size and its power at every step.

123. Once established, therefore, the plant can provide for itself, drawing the needful materials from the earth and the air, and assimilating or organizing them by its own peculiar power. But at the beginning, and until it has sent forth its root into the soil and spread out its first leaves in the light, it must be nourished and grow by means of organized matter supplied by the parent plant. This supply in the Maple was de-



posited in the seed-leaves of the embryo, and was barely sufficient to develop the radicle into a tiny stem, to form a simple root at the lower extremity, and above to expand in the light the pair of small, green seed-leaves; when the plantlet is left to its own resources. Very commonly a larger store of nourishment is provided for the plant's earliest growth. In the almond, for instance (Fig. 108), the large cotyledons are so thickened by this nourishing matter, deposited in their tissue, that they have not the appearance of leaves. It is the same in the Plum and Cherry (Fig. 111^a), and in the Apple, only on a smaller scale (Fig. 110, 111); and the Beech (Fig. 112 - 114) and the Bean (Fig. 115 - 117) afford familiar

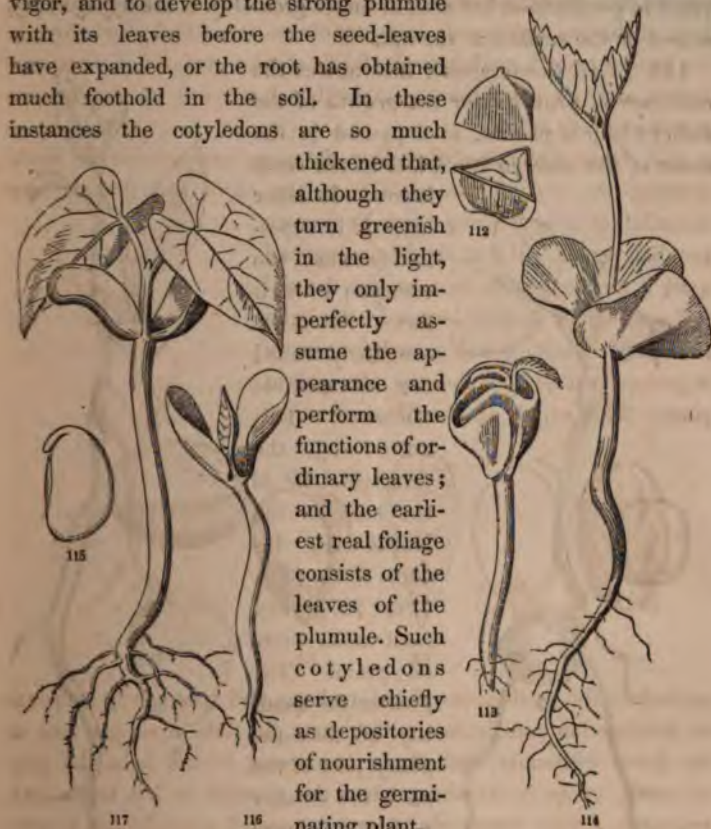
FIG. 108. Embryo (kernel) of the Almond. 109. Same, with one cotyledon removed, to show the plumule, *a*.

FIG. 110. Section of an Apple-seed, magnified, cutting through the thickness of the cotyledons. 111. Embryo of the same, extracted entire, the cotyledons a little separated.

FIG. 111^a. Germination of the Cherry, showing the thick cotyledons little altered, and the plumule developing the earliest real foliage.

illustrations of the kind. The ample store of nourishment in such cases enables the germinating plantlet to grow with remarkable vigor, and to develop the strong plumule with its leaves before the seed-leaves have expanded, or the root has obtained much foothold in the soil. In these instances the cotyledons are so much

thickened that, although they turn greenish in the light, they only imperfectly assume the appearance and perform the functions of ordinary leaves; and the earliest real foliage consists of the leaves of the plumule. Such cotyledons serve chiefly as depositories of nourishment for the germinating plant.



224. Still more strongly marked cases of this kind are presented by the Pea (Fig. 118, 119), the Chestnut and Horsechestnut, the Oak (Fig. 120, 121), &c. Here the cotyledons are excessively thickened, so as to lose all likeness to leaves and all power of fulfilling the office of foliage. Accordingly they remain unchanged within the seed-coats, supplying abundant nourishment to the

FIG. 112. A Beech-nut, cut across. 113. Beginning germination of the Beech, showing the plumule growing before the cotyledons have opened or the root has scarcely formed. 114. The same, a little later, with the second joint lengthened.

FIG. 115. The embryo (the whole kernel) of the Bean. 116. Same early in germination; the thick cotyledons expanding and showing the plumule. 117. Same, more advanced in germination; the plumule developed into a joint of stem bearing a pair of leaves.

plumule, which gives rise to the first leaves that appear. As the radicle itself scarcely if at all elongates, the cotyledons are not elevated in germination but remain under ground (i. e. are *hypogæous*), or rest on the surface of the soil.

125. In all the foregoing illustrations the nourishment provided for the growth of the embryo into a plantlet is deposited in the tissue of the embryo itself, i. e. in the seed-

leaves. In other cases it is deposited around the embryo; when it forms what is commonly called the *Albumen* of the seed. This makes up the principal bulk of the seed in the Buckwheat, Indian Corn (Fig. 126, 127), and most other sorts of grain. The greater the quantity of this, the floury part of the seed, the smaller or less developed is the embryo, or the less thick are its cotyledons.

In the Morning-

Glory, for instance (Fig. 122 - 125), where the embryo is surrounded by mucilaginous albumen, the cotyledons appear in the seed as a pair of very thin and well-formed green leaves. These absorb the nourishment required for the plantlet's earliest growth from

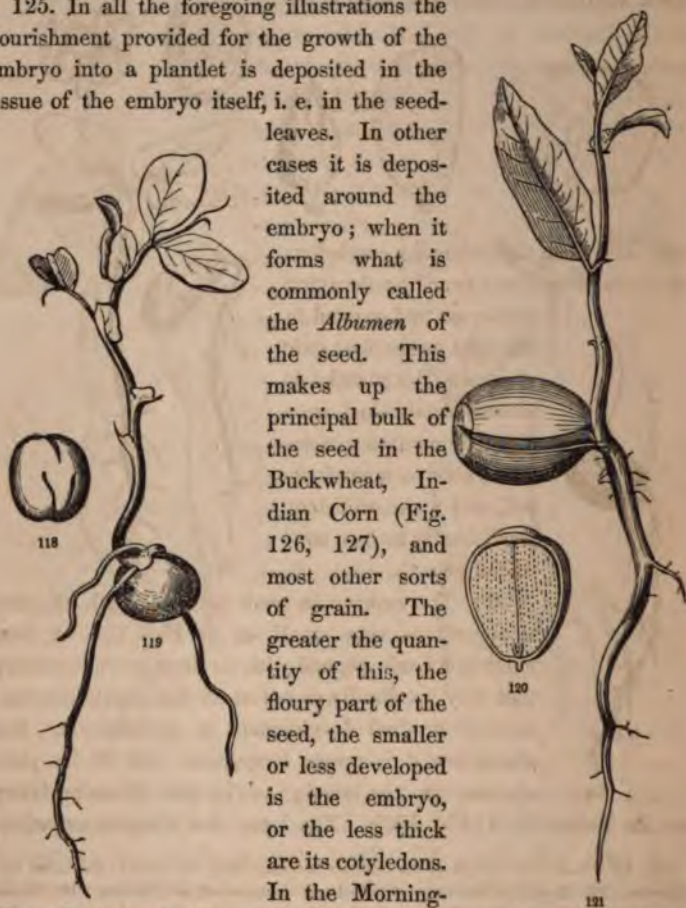


FIG. 118. Embryo of a Pea. 119. The same in germination.

FIG. 120. An acorn, divided lengthwise, showing a section of the very thick and fleshy cotyledons and the very small radicle. 121. Germination of the acorn.

the surrounding albumen, which in germination is gradually liquefied, its starch or amyloid being transformed into dextrine and sugar (80, 82, 83). Thus nourished, the radicle rapidly lengthens into a stem, and develops a root from its lower extremity, connecting it with the

soil; and when the enlarging cotyledons extricate themselves from the decaying seed-coats and expand in the light as the first pair of leaves, the plantlet is already established as a complete miniature vegetable, able to nourish itself, and make sufficient provision for its own continued growth.

126. The embryo in seeds provided with albumen is sometimes very small, as in Fig. 131, or even much more minute, and with its parts so rudimentary that they are hardly or not at all discernible previous to their gradual development in germination. But sometimes it is pretty large, and with all its parts obvious in the seed; as in the Morning-Glory and in Indian Corn (Fig. 122). The latter has a highly organized

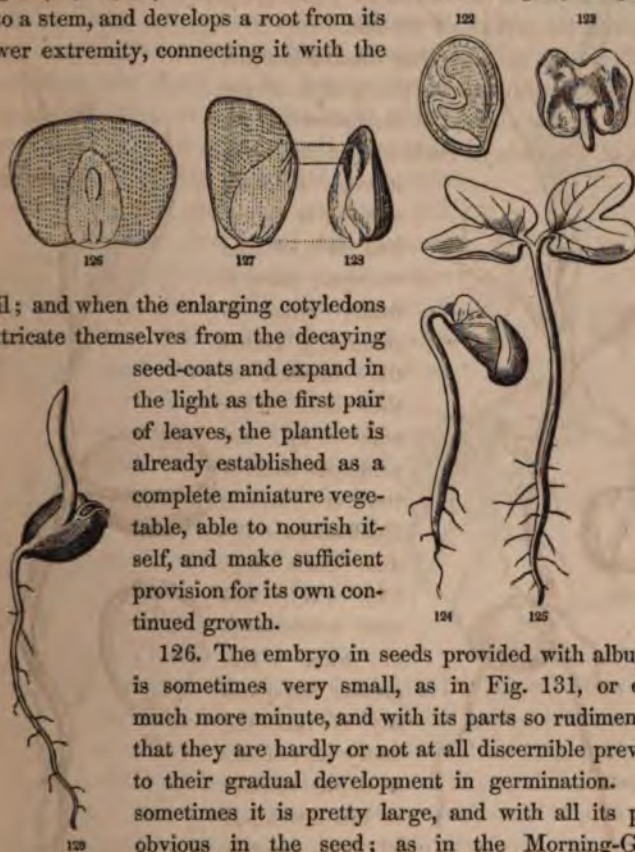
FIG. 122. Seed and embryo of the common Morning-Glory, cut across; the latter seen edgewise. 123. Embryo of the same, detached and straightened, seen flatwise. 124. Germinating Morning-Glory. 125. The same further advanced; its two thin seed-leaves expanded.

FIG. 126. A grain of Indian Corn, seen flatwise, divided through the embryo, which is viewed lying on the albumen, which makes the principal bulk of the seed.

FIG. 127. Another grain of Corn, cut through the middle in the opposite direction, dividing the embryo through its thick cotyledon and its plumule, the latter consisting of two leaves, one enclosing the other.

FIG. 128. The embryo taken out whole: the thick mass is the cotyledon; the narrow body partly enclosed by it is the plumule; the little projection at its base is the very short radicle enclosed in the sheathing base of the first leaf of the plumule.

FIG. 129. A grain of Indian Corn in germination.



embryo, with a strong and well-developed plumule, of several leaves enwrapped one within another; and, being amply nourished by the

copious mealy albumen, it sprouts with remarkable vigor, sending up three or four leaves in rapid succession before the earliest has completed its growth, at the same time sending forth additional roots downwards into the soil. Here also, as in the Pea and the Oak, &c. (124) the germination is *hypogæous*, the cotyledons remaining in the seed underground, and the leaves which appear above ground belonging to the plumule. This is also the case in the Iris (Fig. 132) and most plants of the same class.

But in the Onion the cotyledon (which is single) lengthens, raises the seed out of the ground, and becomes the first leaf.



127. In Indian Corn (Fig. 130), in Iris (Fig. 132), and also in the germinating Cherry (Fig. 111^a), Oak (Fig. 121), and Pea (Fig. 119), the leaves of the plumule succeed one another singly, that is, there is only one upon each joint of stem: in other words, the leaves are *alternate*. Whereas in the seedling Beech and the Bean (Fig. 114, 117) these early leaves are in pairs, that is, are *opposite*. A similar difference is to be noticed in the embryo as to the

128. Number of Cotyledons. All the earlier illustrations are taken from plants which have a pair of cotyledons, or seed-leaves, belonging to the first joint of stem, that is, to the radicle. Such embryos are accordingly said to be *DICOTYLEDONOUS*,—a name expressive of this fact. But in the Lily, Onion, Iris, Indian Corn, and the like, the embryo



FIG. 130. Indian Corn more advanced in germination, and with a cluster of roots.

FIG. 131. Section of a seed of Iris or Flower-de-Luce, magnified, showing the small embryo enclosed in the albumen, near its base. 132. Germinating plantlet of Iris.

has only one cotyledon or true seed-leaf (Fig. 128, &c.); the other leaves, if any are apparent, are enclosed by the cotyledon and belong to the plumule; and the embryo with one cotyledon is accordingly termed **MONOCOTYLEDONOUS**. The difference in this respect coincides with striking differences in the structure of the stems, leaves, and blossoms, and lays a foundation for the division of Flowering or Phænogamous plants (114) into two great Classes.

129. In a few plants, such as Pines, the embryo is provided with from three to ten cotyledons, which expand into a circle of as many green leaves in germination (Fig. 133, 134): such an embryo is said to be **POLYCOTYLEDONOUS**, i. e. of many cotyledons.

130. Having taken this general survey of the development of Phænogamous plants from the seed, and of their common plan of growth, their further development and their morphology may best be studied by examining in succession the three universal organs of vegetation (116) of which they all consist, viz. the Root, Stem, and Leaves.



CHAPTER III.

OF THE ROOT, OR DESCENDING AXIS.

131. The Root is the descending axis (120), or that portion of the body of the plant which grows downwards, ordinarily fixing the vegetable to the soil and absorbing nourishment from it. As already mentioned (121), the root grows in length by continual additions of new fabric to its lower extremity, elongating from that part only or chiefly; so that the tip of a growing root always consists of the most newly formed and active tissue. It begins, in germination, at the root-end of the radicle. That only this extremity of the radicle is root is evident from the mode in which the radicle grows, namely,

FIG. 133. Section of a seed of a Pine, with its embryo of several cotyledons. 134. Early seedling Pine, with its stemlet, displaying its six seed-leaves.

by lengthening throughout every part; which is a characteristic feature of the stem.

132. The root, however, does not grow from its very apex, as is commonly stated; but the new formation (by continued multiplication



tion of cells, 33) takes place just behind the apex (Fig. 135), which consists of an obtusely conical mass of older cells. As these wear away or perish, they are replaced by the layer beneath; and so the advancing point of the root consists, as inspection plainly shows, of older and denser tissue than the portion just behind it. The point of every branch of the root is capped in the same way. It follows that the so-called *spongioles* or *spongelets* of

the roots, or enlarged tips of delicate forming tissue, have no existence. Not only are there no special organs of this sort, but absorption evidently does not take place, to any considerable extent, through the rather firm tissue of the very point itself.

133. **Absorption by Roots.** As the surface of the root, like every part of a plant, consists of closed cells, it is evident that the moisture it so largely takes in must be imbibed through the walls of the cells, by endosmose (40); and that the whole surface of a fresh root will take part in absorption. The newer the root, however, the more actively does it absorb, the cells then having thinner walls. As they become older, the superficial layer of cells thicken their walls and form a kind of skin, or epidermis (69), through which absorption does not take place so freely. Roots accordingly absorb mostly by their fresh tips and the adjacent parts; and these are constantly renewed by growth, and

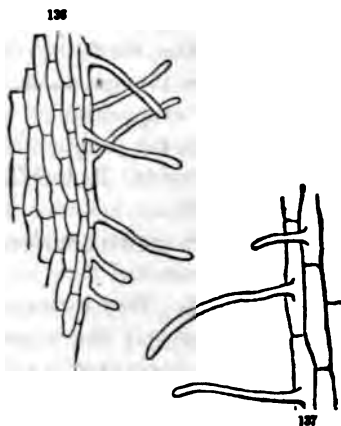


FIG. 135. The tip of the root of a seedling Maple (Fig. 106), magnified: *a*, the place where growth is mainly taking place, by cell-multiplication; *b*, the original tip of the radicle.

FIG. 136, 137. Portions of the surface of the same, highly magnified, showing the nature of the root-hairs or fibrils.

extended farther into the soil. The absorbing surface of the new parts of roots is greatly increased by the

134. *Root-hairs*, or delicate *fibrils* which they bear. These are often discernible by the naked eye, as in the young seedling Maple (Fig. 106), and may almost always be plainly shown by a moderate magnifying power, as in Fig. 135; while a higher power distinctly reveals their nature, as prolongations of some of the superficial cells from a certain point into slender tubes (Fig. 136, 137), thus largely increasing the absorbing surface. As fast as the superficial cells are converted into epidermis, the root-hairs die away, fresh ones taking their place on the newer parts.

135. The advancing extremity of the root consists of parenchyma alone; but vessels and woody tissue appear in the forming root soon after their appearance in the radicle or stemlet above. The arrangement of the woody matter is generally the same as in the stem, except that the root seldom exhibits a distinct pith. The root increases in diameter in the same manner as the stem. (Chap. IV. Sect. IV., V.)

136. The growth of the root and its branches keeps pace with the development of the stem. As the latter shoots upward and expands its leaves, from which water is copiously exhaled during vigorous vegetation, the former grow onward and continually renew the tender tissue through which the absorption, required to restore what is lost by evaporation or consumed in growth, is principally effected. Hence the danger of disturbing the active roots during the season of growth. In early summer, while new branchlets and leaves are developing, and when the sap is rapidly consumed by the fresh foliage, the rootlets are also in rapid action, are extending at a corresponding rate, and their tender absorbing points are most frequently renewed. They cannot now be removed from the soil without injury, at the very time when their action is essential to restore the liquid which is continually exhaled from the leaves. But at the close of summer, as the leaves become inactive and the growth of the season is attained, the rootlets also cease to grow, the epidermis forms a comparatively firm covering quite down to the tip, and absorption at length ceases. This indicates the proper period for transplanting, namely, in the autumn after vegetation is suspended, or in early spring before it recommences.

137. This elongation of roots by their advancing points alone is admirably adapted to the conditions in which they are placed.

Growing as they do in a medium of such unequal resistance as the soil, if roots increased like growing stems, by the elongation of their whole body, they would be thrown, whenever the elongating force was insufficient to overcome the resistance, into knotted or contorted shapes, ill adapted for the free transmission of fluid. But, lengthening only at their farthest extremity, they insinuate themselves with great facility into the crevices or yielding parts of the soil, and afterwards by their expansion in diameter enlarge the cavity; or, when arrested by insuperable obstacles, their advancing points follow the surface of the opposing body until they reach a softer medium. In this manner, too, they readily extend from place to place, as the nourishment in their immediate vicinity is consumed. Hence, also, may be derived a simple explanation of the fact, that roots extend most rapidly and widely in the direction of the most favorable soil, without supposing any self-determining power beyond what belongs to all growing parts. (Chap. XIII.)

138. We have taken the root of the seedling as an example and epitome of that of the whole herb or tree; as we rightly may, for in its whole development the root produces no other parts; it bears nothing but naked branches, which spring from different portions of the surface of the main root, nearly as this sprung from the radicle, and exactly imitate its growth. They and their ramifications are mere repetitions of the original descending axis, serving to multiply the amount of absorbing surface. The branches of the root, moreover, shoot forth irregularly, or at least in no order like that of the branches of the stem, which have a symmetrical arrangement, dependent upon the arrangement of the leaves (166).

139. To the general statement that roots give birth to no other organs, there is this abnormal, but by no means unusual exception, that of producing buds, and therefore of sending up leafy branches. Although not naturally furnished with buds, like the stem, yet, under certain circumstances, the roots of many trees and shrubs, and of some herbs, have the power of producing them abundantly. Thus, when the trunk of a young Apple-tree or Poplar is cut off near the ground, while the roots are vigorous and full of elaborated sap, those which spread just beneath the surface produce buds, and give rise to young shoots. The roots of the Maclura, or Osage Orange, habitually give rise to such irregular or *adventitious* (168) buds and branches.

140. Although the root does not produce ascending axes, or stems,

except in certain rather unusual instances, yet stems habitually produce roots, whenever circumstances favor it, namely, when they are covered by the damp and moist soil, or rest on its surface. Roots accordingly may be distinguished into *primary* and *secondary*.

141. **The Primary Root** is that which originates from the root end of the embryo in germination, including also its branches. If this continues as a main root, it commonly forms a tap-root. But very often the main root, is soon lost in the branches. Sometimes a cluster of roots is produced directly from the lower extremity of the radicle, as in the Pumpkin, and Indian Corn (Fig. 130). In the latter the second and the succeeding short joints of stem also send out roots. These are early instances of

142. **Secondary Roots**, i. e. roots emitted by other parts of the ascending axis than the radicle. Most creeping plants produce them at every joint; and most branches, when bent to the ground and covered with earth, so as to afford the moisture and darkness they require, will strike root. So, often, will separate pieces of young stems, if due care be taken; as when plants are propagated by cuttings. Cryptogamous plants, growing from spores and having no embryo stem or axis to commence with, are furnished with secondary roots only.

143. Viewed as to the duration of the plant, roots are distinguished into *annual*, *biennial*, and *perennial*.

144. **Annual Roots** are those of a plant which springs from the seed, flowers, and dies the same year or season. Such plants always have *fibrous* roots, composed of numerous slender branches, fibres, or rootlets, proceeding laterally from the main or tap-root; or else the whole root divides at once into such fibrous branches, as in all annual Grasses (Fig. 130). These multiplied rootlets are well adapted for absorption from the soil, but for that alone. The food which the roots absorb, after being digested and elaborated in the leaves, is all expended in the production of new leafy branches, and at length of blossoms. The flowering process and the maturing of the fruit exhaust the vegetable greatly (in a manner hereafter to be explained), consuming all the nourishing material which it contains, or storing it up in the fruit or seed for its offspring; and the exhausted plant perishes at the close of the season, or whenever it has fully gone to seed.

145. **Biennial Roots** are those of plants which do not blossom until the second season, and which die when they have matured their

seed. Such plants send up no lengthened stem during the first summer, but produce a large tuft of leaves next the ground, and



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proceed to elaborate what they receive from the roots and from the air into organic or nourishing matter, and store it up in the root, in the form of starch, vegetable jelly, and the like. The root enlarges, or becomes *fleshy*, as this accumulates. In biennials this accumulation generally takes place in the primary or main root, as in the Radish, Carrot, Beet, &c. This, when only moderately thickened and tapering downwards, is a common *tap-root*: when more enlarged and broadest at the crown, or junction with the extremely abbreviated stem, it forms a *conical* root, like that of the common Beet and Parsnip: when broadest in

the middle and tapering to both ends, it is *spindle-shaped* or *fusiform*, as in the Radish (Fig. 138): when much broader than long, and abruptly contracted below, like a turnip, it is *napiform*. Such roots, abounding in nourishment, are appropriated by man for food. The plant itself uses this store for the same purpose. When the vegetation of these biennials is resumed, the following spring, the new shoots, fed by this abundant stock of nourishment provided for them, grow with great vigor, and produce flowers, fruit, and seed almost entirely at its expense; and this stock being exhausted by the time the seeds are matured, when the cells of the great root will be found to be emptied of their contents and dead, the plant perishes.

146. *Perennial Roots* are those of plants which last year after year. In shrubs and trees the roots themselves live and grow indefinitely; but in perennial herbs the same roots seldom survive more than a year or two, and a new set is formed annually. Here, also, a store of nourishment for the vigorous commencement of the succeeding year's growth is not unfrequently deposited in the root. The Sweet Potato, the Peony, and the Dahlia (Fig. 139), furnish good illustrations of the kind. These roots are generally *fascicled* or *clustered*; that is, they consist of a cluster of roots from the base of the stem.

FIG. 138. Fusiform root of the Radish, with some foliage.

While some of these remain slender and serve merely for absorption, others, thickened by this deposit, may become *tuberous* (as in Fig. 139); and buds, formed on the stem just above, draw upon this store when they start into growth in the spring. These particular roots perish when exhausted of their store; but new accumulations have meanwhile been formed in some of the roots of the season, which serve the same purpose the following spring; and so the plant survives, year after year.

147. Some less ordinary modifications of roots remain to be noticed. It has already been stated that they may spring (as secondary roots, 142) from any part of the stem, although they commonly do so only when this rests on or is covered by the soil, which affords the darkness and moisture congenial to them. Some stems, however, strike root freely in the open air, forming



148. **Aerial Roots.** The Ivy of Europe, our own Poison Ivy (*Rhus Toxicodendron*), and the Trumpet Creeper climb by such roots, in the form of small rootlets, which attach themselves to the bark of trees, &c. These serve merely for mechanical support. Other plants produce larger aerial roots, which, emitted from the stem in the open air, descend to the ground and establish themselves in the soil. This may be observed, on a small scale, in the stems of Indian Corn, where the lower joints often produce roots which grow to the length of several inches before they reach the ground. More remarkable cases of the kind abound in those tropical regions where the sultry air, saturated with moisture for a large part of the year, favors the utmost luxuriance of vegetation. The Pandanus or Screw-Pine (a Palm-like tree, often cultivated in our conservatories) affords a well-known instance. Here (Fig. 140) strong roots, emitted in the open air from the lower part of the trunk, and soon reaching the soil, give the tree the appearance of having been partially raised out of the ground. The famous Banyan-tree of India (Fig. 142) affords a still more striking illustration. In this the

FIG. 139. Fascicled tuberous roots of the Dahlia.

aerial rootlets strike from the horizontal branches of the tree, often at a great height, at first swinging free in the air, but finally reach-

ing and establishing themselves in the ground, where they increase in diameter and form accessory trunks, surrounding the original boll and supporting the wide-spread canopy of branches and foliage. Very similar is the economy of the Mangrove (Fig. 141), which forms impenetrable thickets on low and muddy sea-shores in the tropics, and even occurs on the coast of Florida and Lou-



isiana. Here aerial roots spring not only from the main trunk, as in the Pandanus, but also from the branchlets, as in the Banyan.



FIG. 140. The Pandanus, or Screw-Pine; with, 141, a Mangrove-tree (*Rhizophora Mangle*).
FIG. 142. The Banyan-tree, or Indian Fig (*Ficus Indica*).

Moreover, this tendency to shoot in the air is shown even in the embryo, which begins to germinate while the fruit is yet attached to the parent branch, often elongating its radicle to the length of a foot or more before the fruit falls to the ground.

149. Epiphytes, or Air-Plants, exhibit a further peculiarity. Their roots not only strike in the open air, but throughout their life have no connection with the soil. These generally grow upon the trunks and branches of trees; their roots merely adhering to the bark to fix the plant in its position, or else hanging loose in the air, from which such plants draw all their nourishment. Of this kind are a large portion of the gorgeous Orchidaceous plants of very warm and humid climes, which are so much prized in hot-houses, and which, in their flowers as well as their general aspect, exhibit such fantastic and infinitely varied forms. Some of the flowers resemble butter-



flies, or strange insects, in shape as well as in gaudy coloring; such, for example, as the *Oncidium Papilio* (Fig. 143). To another

FIG. 143. *Oncidium Papilio*, and, 144, *Comparettia rosea*; two epiphytes of the Orchid family; showing the mode in which these Air-plants grow.

family of Epiphytic plants belongs the *Tillandsia*, or Long Moss, which, pendent in long and gray tangled clusters or festoons from the branches of the Live-Oak or Long-leaved Pine, gives such a peculiar and sombre aspect to the forests of the warmer portions of our Southern States. They are called Air-plants, in allusion to the source of their nourishment; and Epiphytes, from their growing upon other plants, and in contradistinction to

150. *Parasites*, that not only grow upon other vegetables, but live at their expense; which Epiphytes do not. *Parasitic plants* may be divided into two sorts, viz.:—1st, those that have green foliage; and 2d, those that are destitute of green foliage. They may vary also in the degree of parasitism; some being absolutely dependent upon the foster plant for nourishment, while others, such as the Cursed Fig (*Clusia rosea*) of Tropical America, often take root in the soil, and thence derive a part of their support. The latter occurs only in

151. *Green Parasites*, or those furnished with green foliage, or proper digestive organs of their own. These strike their roots



through the bark and directly into the new wood of the foster plant; whence they draw the ascending, mostly crude sap, which

they have to assimilate in their own green leaves. The Mistletoe is the most familiar example of this class. It is always completely parasitic, being at no period connected with the



earth; but the seed germinates upon the trunk or branch of the

FIG. 145. Roots of *Gerardia flava*; some of the rootlets attaching themselves parasitically to the root of a Blueberry. (From a drawing by Mr. J. Stauffer.)

FIG. 146. Section of one of the attached rootlets, showing the union.

tree where it happens to fall, and its nascent root, or rather the woody mass that it produces in place of the root, penetrates the bark of the foster stem, and forms as close a junction with its young wood as that of a natural branch. The Cursed Fig, commonly beginning as a parasite, sends down aerial roots, some of which strike into the wood of the foster tree lower down, while others descend to the ground and draw from it a portion of their sustenance in the ordinary manner. Some common herbaceous plants, hitherto not suspected of such habits, have recently been found to fix themselves clandestinely, under ground, by means of some of their rootlets, to the roots of neighboring plants, and furtively draw from them a portion of their sustenance. This is the case with our Comandra, as well as with the Thesiums of the Old World, and also with our Gerardias and many other plants of that family, which have long been known as uncultivable, although the cause of their being so has only lately been detected. It would appear that this partial parasitism is necessary to their existence. Gerardia appears to implant its rootlets upon the bark of the roots of neighboring shrubs, and therefore to steal elaborated sap (Fig. 145, 146).

152. *Pale or Colored Parasites*, such as Beech-Drops, Pine-Sap, &c., are those which are destitute of green herbage, and are usually of a white, tawny, or reddish hue; in fact, of any color except green. These strike their roots, or sucker-shaped discs, into the bark, mostly that of the root, of other plants, and thence draw their food from the sap already elaborated. They have accordingly no occasion for digestive organs of their own, i. e. for green foliage. The Dodder (Fig. 147) is a common plant of this kind which is parasitic above ground. Its seeds germinate in the earth; but when the slender twining stem reaches the surrounding



FIG. 147. The common Dodder of the Northern States (*Cuscuta Gronovii*), of the natural size, parasitic upon the stem of an herb: the uncoiled portion at the lower end shows the mode of its attachment. 148. The coiled embryo taken from the seed, moderately magnified. 149. The same in germination; the lower end elongating into a root, the upper into a thread-like leafless stem.

herbage, it forms suckers, which attach themselves firmly to the surface of the supporting plant, penetrate its epidermis, and feed upon its juices; while the original root and base of the stem perish, and the plant has no longer any connection with the soil. Thus stealing its nourishment ready prepared, it requires no proper digestive organs of its own, and, consequently, does not produce leaves. This economy is foreshadowed in the embryo of the Dodder, which is a naked thread spirally coiled in the seed (Fig. 148, 149), and presenting no vestige of cotyledons or seed-leaves. A species of Dodder infests and greatly injures flax in Europe, and sometimes makes its appearance in our own flax-fields, having been introduced with the imported seed. Such parasites do not live upon all plants indiscriminately, but only upon those whose elaborate juices furnish a propitious nourishment. Some of them are restricted, or nearly so, to a particular species; others show little preference, or are found indifferently upon several species of different families. Their seeds, in some cases, it is said, will germinate only when in contact with the stem or root of the species upon which they are destined to live. Having no need of herbage, such plants may be reduced to a stalk bearing a single flower (Fig. 965) or a cluster of flowers (Fig. 968), or even to a single blossom developed from a bud directly parasitic on the bark of the foster plant. Of this kind are the several species of *Pilostyles* (parasitic flowers on the shoots of Leguminous plants) in Tropical America, one species of which was recently discovered by Mr. Thurber near the southern borders of New Mexico. Here the flowers are small, only about a quarter of an inch in diameter. The most wonderful plant of this kind is that vegetable Titan, the *Rafflesia Arnoldi* of Sumatra (Fig. 150), which grows upon the stem of a kind of Grape-vine. It is a parasitic flower, measuring



FIG. 150. *Rafflesia Arnoldi*; an expanded flower, and a bud, directly parasitic on the stem of a vine: reduced to the scale of half an inch to a foot.

nine feet in circumference, and weighing fifteen pounds! Its color is light orange, mottled with yellowish-white.

153. Among Cryptogamous plants, numerous Fungi are parasitic upon living, especially upon languishing vegetables; others infest living animals; the rest feed on dead or decaying vegetable or animal matters: all are destitute of chlorophyll or anything like green herbage. It is probable that our *Monotropa*, or Indian Pipe, a pallid Phanogamous plant, looking like a Fungus, actually lives like one, and draws its nourishment, at least in great part, from the decaying leaves among which it grows.

CHAPTER IV.

OF THE STEM, OR ASCENDING AXIS.

SECT. I. ITS GENERAL CHARACTERISTICS AND MODE OF GROWTH.

154. THE STEM is the ascending axis, or that portion of the trunk which in the embryo grows in an opposite direction from the root, seeking the light, and exposing itself as much as possible to the air. All Phanogamous plants (114) possess stems. In those which are said to be *acaulescent*, or *stemless*, it is either very short, or concealed beneath the ground. Although the stem always takes an ascending direction at the commencement of its growth, it does not uniformly retain it; but sometimes trails along the surface of the ground, or burrows beneath it, sending up branches, flower-stalks, or leaves into the air. The common idea, that all the subterranean portion of a plant belongs to the root, is by no means correct.

155. The root gives birth to no other organs, but itself directly performs those functions which pertain to the relations of the vegetable with the soil;—its branches bind the plant to the earth; its newly formed extremities or rootlets imbibe nourishment from it. But the aerial functions of vegetation are chiefly carried on, not so much by the stem itself as by a distinct set of organs which it bears, namely, the leaves. Hence, the production of leaves is one of the

characteristics of the stem. These are produced only at certain definite and symmetrically arranged points, called

156. **Nodes**, literally *knots*, so named because the tissues are here more or less condensed, interlaced, or interrupted, as is conspicuously seen in the Bamboo, in a stalk of Indian Corn, or of any other Grass. Here each node forms a complete ring, because the leaf arises from the whole circumference of the stem at that place. When the base of the leaf or leaf-stalk occupies only a part of the circumference, the nodes are not so distinctly marked, except by the leaves they bear, or by the scars left by their fall (Fig. 151, &c.) They are often called joints, and sometimes, indeed, the stem is actually *jointed*, or *articulated*, at these points; but commonly there is no tendency to separate there. Each node bears either a single leaf (as in Fig. 111, 121, &c.), or two leaves placed on opposite sides of the stem (as in Fig. 107), or else three or more, placed in a ring (in botanical language, a *whorl* or *verticil*) around the stem. The naked portions or spaces that intervene between the nodes are termed

157. **Internodes**. The undeveloped stem is, in fact, made up of a certain number of these leaf-bearing points, separated by short intervals; and its growth consists, primarily, in the successive elongation of these internodes so as to separate the nodes more or less, and allow the leaves to expand.

158. This brings to view the leading peculiarity of the stem; namely, that it is formed of a succession of similar parts, developed one upon the summit of another, each with its own independent growth. Each developing internode, moreover, lengthens throughout its whole body, unlike the root, which elongates continuously from its extremity alone (121). To have a good idea of this, we have only to observe the gradual evolution of a germinating plant, where each internode develops nearly to its full length, and expands the leaf or pair of leaves it bears, before the elongation of the succeeding one commences. As already described (120, &c.), the radicle, or internode which pre-exists in the embryo, elongates, and raises the seed-leaves into the air; they expand and elaborate the material for the next joint, the leaves of which in turn prepare the material for the third, and so on. The internode lengthens principally by the elongation of its already formed cells, particularly in its lower part, which continues to grow after the upper portion
shed.

159. Buds. The apex of the stem, accordingly, is always crowned with an undeveloped portion, with rudimentary parts similar to those already unfolded, that is, with a BUD. The embryo itself may be viewed as an internode (the radicle) bearing the fundamental bud (the plumule) on its apex, from which the whole plant is developed, just as an ordinary bud of a tree or shrub develops to form the growth of the season. Except that, in the latter case, the different steps follow each other more closely; for the bud usually has a considerable number of parts ready formed in miniature before it begins to grow, and has a full store of assimilated sap accumulated in the parent stem to feed upon. This is no less the case in many strong embryos highly developed in the seed, and supplied with abundant nourishment, either in the cotyledons, as in the Pea (Fig. 119) and Oak (Fig. 120), or in the albumen, as in Indian Corn (Fig. 126-130). The strong buds which in many shrubs and trees crown the apex of a stem when it has completed its growth for the season, often exhibit the whole plan and amount of the next year's growth; the nodes, and even the leaves they bear, being already formed, and only requiring the elongation of the internodes for their full expansion. This is rudely shown in the annexed diagrams, Fig. 151, 152. As the bud (Fig. 153) is well supplied with nourishment in spring by the stem on which it rests, its axis elongates rapidly; and although the growth commences with the lowest internode, yet the second, third,

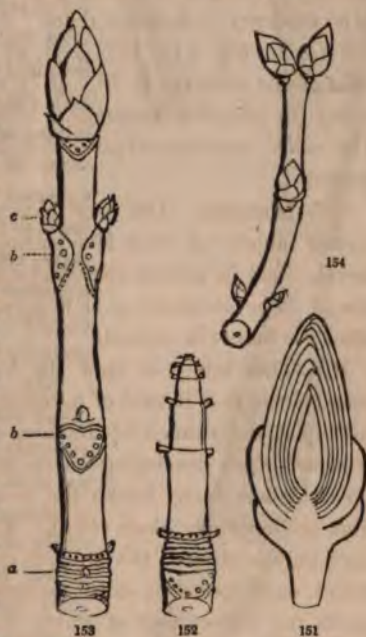


FIG. 151. Diagram of the vertical section of a strong bud, such as that of Horsechestnut.

FIG. 152. The axis of the same developing, the elongation beginning with the lowest internode, soon followed by the others in succession.

FIG. 153. A year's growth of Horsechestnut, crowned with a terminal bud: *a*, scars left by the bud-scales of the previous year; *b*, scars left by the fallen leafstalks; *c*, axillary buds.

FIG. 154. Branch and buds (all axillary) of the lilac.

THE STEM,

and fourth internodes, &c. have begun to lengthen long before the first has attained its full growth. The stem thus continued from the previous bud is, if it survive, again terminated with a similar bud



at the close of the season, which in its development repeats the same process. A set of narrow rings on the bark (Fig. 153, *a*) commonly mark the limit of each year's growth. These are the scars left by the fall of the scales of the bud; and these, in the Horsechestnut, and other trees with large scaly buds, may be traced back on the stem for a series of years, growing fainter with age, until they are at length obliterated by the action of the weather and the distention caused by the increase of the stem in diameter. The same is the case with the more conspicuous *leaf-scars*, or, marks on the bark left by the separation of the leaf-stalk, which are for a long time conspicuous on the shoots of the Horsechestnut (Fig. 153, *b*) and the Magnolia (Fig. 155).

160. A bud, therefore, is nothing more than the first stage in the development of a stem, with the axis still so short that the rudimentary leaves within successively cover each other, while the whole is covered and protected by the scales without. Buds vary greatly, however, in size, appearance, and degree of development. Those of many shrubs and trees are minute, and hidden by the bark until their vernal growth commences, as in

FIG. 155. Branch of Magnolia Umbrella, of the natural size, crowned with the terminal bud; and below exhibiting the large, rounded leaf-scars, as well as the rings or annular scars left by the fall of the bud-scales of the previous season. 156. A detached scale from a similar bud; its thickened axis is the base of a leafstalk; the membranous sides consist of the pair of pates.

Sumac, Locust, Honey-Locust (Fig. 164), &c.: in these buds the parts are few and very rudimentary, and are mostly formed as they develop. In some, they are *naked*, that is, are entirely destitute of protecting scales, and exhibit the forming leaves directly exposed to the air, just as they are in herbs. This occurs in many tropical trees, but not in all, and in some shrubs of cold climates, such as our *Viburnum nudum* and *V. lantanoides*. But the greater number of plants which have a winter to endure are provided with *scaly buds*. Those of Beech and Hickory, as well as of Horsechestnut and Magnolia already referred to, are conspicuous and well-developed examples. The scales serve to protect the tender parts within against injury from moisture and from sudden changes in temperature during the dormant state. To ward off moisture more effectually, they are sometimes coated with a waxy, resinous, or balsamic exudation, as is conspicuous on the scales of the Horsechestnut, Balsam-Poplar or Balm of Gilead, and Balsam-Fir. To guard against sudden changes of temperature, they are often lined, or the rudimentary leaves within invested with non-conducting down or wool.

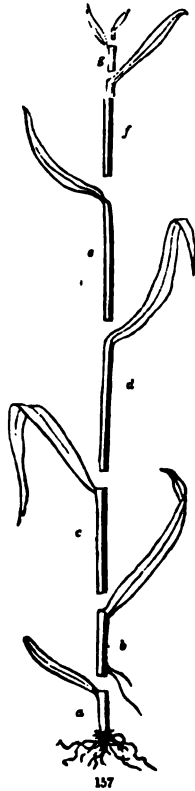
161. The *bud-scales* themselves are leaves in a modified state. This is evident from their situation and arrangement, which are the same as of the proper leaves of the species, and by the gradual transitions from the former to the latter in many plants. In the *turions*, or subterranean budding shoots of numerous perennial herbs, and in the unfolding buds of the Lilac and Sweet Buckeye (*Æsculus parviflora*), every gradation may be traced between bud-scales and foliage, showing that no absolute line can be drawn between them, but that the two are essentially of the same nature, i. e. are different modifications of the same organ.

162. *Plan of Vegetation*. In fact, a simple stem bears nothing but leaves in some form or other, and its branches are only repetitions of itself, following the same laws. The embryo consists of a primary joint of stem crowned with a bud, the first leaves or leaf of which takes the special form of *cotyledons*; the following ones develop as ordinary foliage, and leaf after leaf, or pair after pair, is formed and elevated upon the successive internodes as the stem is built up. At the close of the growing season, if the stem is to endure, this is terminated, as it began, by a bud; and the bud-scales, if any, are leaves developed in this peculiar form, subservient to protection alone, and borne upon nodes which are never separated

by elongation of the internodes. With the ensuing spring growth recommences, and another set of internodes, and of nodes bearing ordinary leaves, form the second year's growth, like the first; and so, by annual increments, a simple leafy stem is developed and carried up. Not only is the whole stem growing from year to year thus composed of a succession of similar growths, each the offspring

of the preceding and the parent of the next, but also each annual growth itself consists of a lineal succession of similar parts, viz. of leaf-bearing joints of stem, developed each upon its predecessor, and in turn surmounted by the next in the series. These *similar parts*, which by their repetition make up the Phænogamous plant, have been termed

163. *Phytons* (from the Greek *φύρον*, plant), or *plant-elements*. The first phyton is the radicle of the embryo, with its cotyledon or pair of cotyledons, from its base developing the root, from above expanding its leaf or pair of leaves (as already described in detail, 119–122), and then giving birth to the next phyton, or joint of stem and leaf, and so on, in lineal succession. So that the whole herb, shrub, or tree, as to its upward growth, is a multiplication of the simple plantlet it began with as it developed from the seed. Moreover, any joint of stem, when favorably situated for the purpose, may produce secondary roots (142), and thus complete the vegetable individuality, having all the organs of vegetation (116).



164. The repetition of these similar parts in the direct line, each from the summit of its predecessor, builds up a simple or main stem, to which many plants are restricted during the first year's growth, and some, such as Palms and Reeds, throughout their whole existence. Their production from new starting-points gives rise to *branches*.

FIG. 157. Diagram of a simple-stemmed plant, like a Grass, and of the similar parts, or phytons, a to g, of which it is composed.

SECT. II. RAMIFICATION.

165. **Branches** spring from *lateral* or *axillary buds*. These are new growing points, which habitually appear, or at least may appear, one (or occasionally two or three) in the *axil* of each leaf, — that is, in the upper angle which the leaf forms with the stem. (See Fig. 153, *c*, where the point at which the fallen leaves were attached is marked by the broad scar, *b*, just below the bud.) When these buds grow, they give rise to **BRANCHES**; which are repetitions, as it were, of the main stem, growing just as that did from the seed; excepting merely, that, while that was implanted in the ground, these proceed from the parent stem. The branches are in turn provided with similar buds in the axils of their leaves, capable of developing into branches of a third order, and so on indefinitely, producing the whole ramification of the plant. The ultimate ramifications are termed **BRANCHLETS**.

166. The arrangement of axillary buds depends upon that of the leaves. When the leaves are *opposite* (that is, two on each node, placed on opposite sides of the stem), the buds in their axils are consequently *opposite*; as in the Maple, Horsechestnut (Fig. 153), Lilac (Fig. 154), &c. When the leaves are *alternate*, or one upon each node, as in the Apple, Poplar, Oak, Magnolia (Fig. 155), &c., the buds implicitly follow the same arrangement. Branches, therefore, being developed axillary buds, their arrangement follows that of the leaves. When the leaves are alternate, the branches will be alternate; when the leaves are opposite, *and the buds develop regularly*, the branches will be opposite. But the perfect symmetry of the ramification, thus provided for, is frequently obscured by the

167. **Non-development of some of the Buds.** As the original bud of the embryo remains for a time latent in the seed, growing only when a conjunction of favorable circumstances calls its life into action, so also many of the buds of a shrub or tree may remain latent for a long time, and many of them fail to grow at all. In our trees, most of the lateral buds generally remain dormant for the first season: they appear in the axils of the leaves early in summer, but do not grow into branches until the following spring; and even then only a part of them usually grow. Sometimes the failure occurs without appreciable order; but it often follows a nearly uniform rule in each species. Thus, when the leaves are opposite, there are

usually three buds at the apex of a branch: namely, the terminal, and one at the end of each part. But it seldom happens that all three develop at the same time. Sometimes the terminal bud consumes the branch, the two lateral generally remaining latent, as in the *Broomrape* (Fig. 153). Sometimes the terminal one regularly falls, and the lateral ones grow, when the stem annually becomes re-shooted, as in the *Willow* (Fig. 154). The undeveloped buds do not necessarily perish, but are ready to be called into action in case the others are checked. When the terminal buds are destroyed some of the lateral ones would also remain dormant, develop in their stead, incited by the abundance of nourishment, which the former would have monopolised. In this manner our trees are soon revivified with verdure, after their tender foliage and branches have been killed by a late vernal frost, or other injury. And buds which have remained latent for several years occasionally shoot forth into branches from the sides of old stems. Such branches, however, more commonly originate from irregular, accidental, or, as they are named

168. Adventitious Buds. It has been already remarked, that roots, although naturally destitute of buds, do yet produce them in certain plants, especially when wounded (159). So likewise do the stems of some shrubs and trees, especially when surcharged with sap, as is commonly seen in Willows and Lombardy Poplars. Here buds break out habitually on the sides of trunks, at least when they are wounded or *pollarded*, or spring from the cut surface where the bark and wood join. These adventitious buds do not originate from nodes, nor affect any order in their appearance, but are wholly casual as to the point of origin. Thus the predestined symmetry of the branches is obscured or interfered with in two distinct ways; first, by the failure of a part of the regular buds to develop; and secondly, by the irregular and casual development of buds from other parts than the axils of the leaves: to which we may add, that great numbers of branches perish and fall away after they have begun to grow. There is still another source of irregularity, namely, the production of

169. Accessory Buds. These are, as it were, *multiplications* of the regular axillary bud, giving rise to two, three, or more buds, instead of one; in some cases situated one above another, in others side by side. In the latter case, which occurs occasionally in the Hawthorn, in certain Willows, in the Maples (Fig. 158), &c., the axillary bud

seems to divide into three, or itself give rise to a lateral bud on each side. On some shoots of the Tartarean Honeysuckle (Fig. 160) from three to six buds appear in each axil, one above another, the lower being successively the stronger and earlier produced, and the one immediately in the axil, therefore, grows in preference: occasionally two or more of them grow, and superposed accessory branches result. It is much the same in *Aristolochia Siphon*, except that the uppermost bud is there strongest. So it is in the Butternut (Fig. 159), where the true axillary bud is minute and usually remains latent, while the accessory ones are considerably remote, and the uppermost, which is much the strongest, is far out of the axil; this usually develops, and gives rise to an *extra-axillary* branch.

170. Excurrent and Deliquescent Stems.

Sometimes the primary axis is prolonged without interruption, by the continued evolution of a terminal bud, even through the whole life of a tree (unless accidentally destroyed), forming an undivided main trunk, from which lateral branches proceed; as in most Fir-trees. Such a trunk is said to be *excurrent*. In other cases the

main stem is arrested, sooner or later, either by flowering, by the failure of the terminal bud, or by the more vigorous development of some of the lateral buds; and thus the trunk is dissolved into branches, or is *deliquescent*, as in the White Elm and in most of

our deciduous-leaved trees. The first naturally gives rise to conical



FIG. 158. Branch of Red Maple, with triple axillary buds, placed side by side.

FIG. 159. Piece of a branch of the Butternut, with accessory buds placed one above another: *a*, the leaf-scar; *b*, proper axillary bud; *c*, *d*, accessory buds.

FIG. 160. Part of a branch of Tartarean Honeysuckle, with crowded accessory buds in each axil.



or spire-shaped trees; the second, to rounded or spreading forms. As stems extend upward and evolve new branches, those near the base, being overshadowed, are apt to perish, and thus the trunk becomes naked below. This is well seen in the excurrent trunks of Firs and Pines, which, when grown in forest, seem to have been branchless for a great height. But the knots in the centre of the trunk are the bases of branches, which have long since perished, and have been covered with a great number of annual layers of wood, forming the *clear stuff* of the trunk.

171. **Definite and Indefinite Annual Growth of Branches.** In the larger number of our trees and shrubs, especially those with scaly buds, the whole year's growth is either already laid down rudimentally in the bud (159), or else is early formed, and the development is completed long before the end of summer; when the shoot is crowned with a vigorous terminal bud, as in the Horsechestnut (Fig. 158) and Magnolia (Fig. 155), or with the uppermost axillary buds, as in the Lilac (Fig. 154) and Elm. Such *definite* shoots do not die down at all the following winter, but grow on directly, the next spring, from these terminal or upper buds, which are generally more vigorous than those lower down. In other cases, on the contrary, the branches grow onward *indefinitely* through the whole summer, or until arrested by the cold of autumn: they mature no buds at or near their summit; or at least the lower and older axillary buds are more vigorous, and alone develop into branches the next spring; the later-formed upper portion most commonly perishing from the apex downward for a certain length in the winter. The Rose and Raspberry, and among trees the Sumac and Honey Locust, are good illustrations of this sort; and so are most perennial herbs, their stems dying down to or beneath the surface of the ground, where the persistent base is charged with vigorous buds, well protected by the ground, for the next year's vegetation.

172. **Propagation from Buds.** Buds, being, as it were, new individuals springing from the original stem, may be removed and attached to other parts of the parent trunk, or to that of another individual of the same, or even of a different, but nearly related species, where they will grow equally well. This is directly accomplished in the operation of *budding*. In *ingrafting*, the bud is transferred, along with a portion of the shoot on which it grew. Moreover, as the cut end of such shoots, when buried in moist and warm soil, will commonly, under due care, send out adventitious

roots, they may be made to grow independently, drawing their nourishment immediately from the soil, instead of indirectly through the parent trunk. This is done in the propagation of plants by cuttings. The great importance of these horticultural operations depends chiefly on the well-known fact, that buds propagate *individual peculiarities*, which are commonly lost in raising plants from the seed.

SECT. III. THE KINDS OF STEM AND BRANCHES.

173. ON the size and duration of the stem the oldest and most obvious division of plants is founded, namely, into Herbs, Shrubs, and Trees.

174. **Herbs** are plants in which the stem does not become woody and persistent, but dies annually or after flowering, down to the ground at least. The difference between *annual*, *biennial*, and *perennial* herbs has already been pointed out (144-146). The same species is so often either annual or biennial, according to circumstances or the mode of management, that it is convenient to have a common name for plants that flower and fruit but once, at whatever period, and then perish: such De Candolle accordingly designated as **MONOCARPIC** plants; while to perennials, whether *herbaceous* or *woody*, large or small, he applied the counterpart name of **POLYCARPIC** plants, signifying that they bear fruit an indefinite number of times.

175. **Undershrubs**, or *suffruticose* plants, are woody plants of humble stature, their stems rising little above the surface. If less decidedly woody, they are termed *suffrutescent*.

176. **Shrubs** are woody plants, with stems branched from or near the ground, and less than five times the height of a man. Between shrubs and trees there is every intermediate gradation. A shrub which approaches a tree in size, or imitates it in aspect, is said to be *arborescent*.

177. **Trees** are woody plants with single trunks, which attain at least five times the human stature.

178. A **Culm** is a name applied to the peculiar jointed stem of Grasses and Sedges, whether herbaceous, as in most Grasses, or woody or arborescent, as in the Bamboo.

179. A **Caudex** is a name usually applied to a Palm-stem (Fig.

184), to that of a Tree Fern (Fig. 100), and to any persistent, erect or ascending, root-like forms of main stems.

180. Those stems which are too weak to stand upright, but recline on the ground, rising, however, towards the extremity, are said to be *decumbent*: if they rise obliquely from near the base, they are said to be *ascending*. When they trail flat on the ground, they are *procumbent*, *prostrate*, or *running*; and when such stems strike root from their lower surface, as they are apt to do, they are said to be *creeping*, or *repent*. They are *climbing* when they cling to neighboring objects for support; whether by tendrils, as the Vine and Passion-flower, by their leafstalks, as the Virgin's Bower (Clematis), or by aerial rootlets, as the Poison Oak (Rhus); and *twining*, or *volute* plants, when they rise, like the Convolvulus, by coiling spirally around stems or other bodies within their reach. Other modifications of the stem or branches have received particular names, some of which merit notice from having undoubtedly suggested several operations by which the cultivator multiplies plants.

181. A *Stolon* is a branch which naturally curves or falls down to the ground, where, favored by shade and moisture, it strikes root, and then forms an ascending stem, capable of drawing its nourishment directly from the soil, and, by the perishing of the portion which connects it with the parent stem, at length acquiring an entirely separate existence. The Currant, Gooseberry, &c., multiply in this way, and doubtless suggested to the gardener the operation of *layering*; in which he not only takes advantage of and accelerates the attempts of nature, but incites it in species which do not ordinarily multiply in this manner.

182. A *Sucker* is a branch of subterranean origin, which, after running horizontally and emitting roots in its course, at length, following its natural tendency, rises out of the ground and forms an erect stem. The Rose, the Raspberry, and the Mint afford familiar illustrations, as well as many other species which shoot up stems "from the root," as is generally thought, but really from subterranean branches. Cutting off the connection with the original root, the gardener propagates such plants *by division*.

183. A *Runner*, of which the Strawberry furnishes the most familiar example, is a prostrate, slender branch, sent off from the base of the parent stem, which strikes root at its apex, and produces a tuft of leaves; thus giving rise to an independent plant capable of extending itself in the same manner.

184. An *Offset* is a similar, but short, prostrate branch, with a tuft of leaves at the end, which, resting on the ground, there takes root, and at length becomes independent; as in the *Houseleek*.

185. A *Tendril* is commonly a thread-like, leafless branch, capable of coiling spirally, by which some climbing plants attach themselves to surrounding bodies for support; as in the *Grape-vine* (Fig. 161). But sometimes tendrils belong to the leaves, as in the *Pea*; when they are slender prolongations of the leafstalk. Some tendrils cling by hooking their tips around the supporting object. Others, such as those of the *Virginia Creeper* (Fig. 162, 163), commonly expand the tips of the tendrils into a flat disc, — much as do many aerial rootlets (as those of *Ivy*) when subservient to the same office, — which firmly adheres to walls or the bark of trees, thus enabling the plant to ascend and cover their surface. As soon as they are attached, the *tendril*



FIG. 161. End of a shoot of the *Grape-vine*, with young tendrils.

FIG. 162. A portion of a stem of *Ampelopsis*, or *Virginia Creeper*, with a leaf and a tendril.

FIG. 163. Ends of the latter, enlarged, showing the expanded tips by which they cling.

usually shortens itself by coiling spirally, thus drawing up the climbing shoot closer to the supporting object.

186. A Spine or Thorn is an imperfectly developed, indurated, leafless branch of a woody plant, attenuated to a point. The nature of

spines is manifest in the Hawthorn (Fig. 165), not only by their position in the axil of a leaf, but often by producing imperfect leaves and buds. And in the Sloe, Pear, &c., many of the stunted branches become *spinose* or *spinescent* at the apex, tapering off gradually into a rigid, leafless point, thus exhibiting every gradation between a spine and an ordinary branch. These spinose branches are less liable to appear on the cultivated tree, when duly cared for, such branches being thrown mostly into more vigorous growth. In the Hawthorn, the spines spring from the main axillary bud, while accessory buds (169), one on each side, appear, and one or both grow the next season into an ordinary

branch. In the Honey Locust, it is the uppermost of several accessory buds, placed far above the axil, that develops into the thorn (Fig. 164). And here the spine itself branches, and sometimes becomes extremely compound. Sometimes the stipules of the leaves develop into spines, as in the Prickly Ash. Sometimes the leaf itself is developed as a spine; of which the Barberry affords a familiar example. When the spine is situated in the axil of a leaf or a leaf-scar, it is necessarily of the nature of a branch. When it bears a

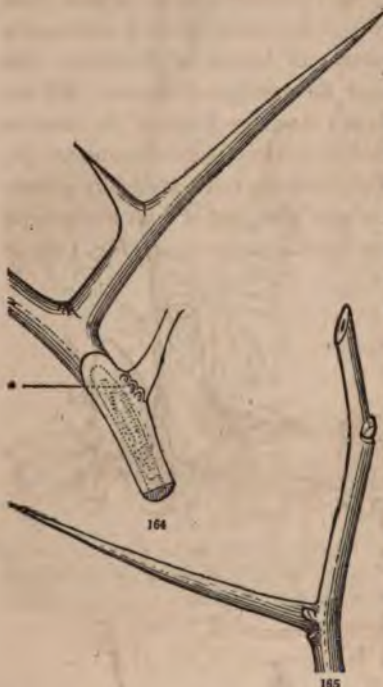
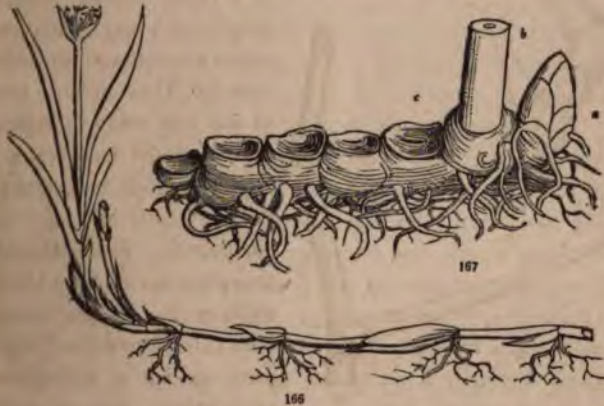


FIG. 164. Branching thorn of the Honey Locust (*Gleditschia*), an indurated branch developed from an accessory bud produced above the axil. *a*, Three buds under the base of the leafstalk, brought to view in a section of the stem and leafstalk below.

FIG. 165. Thorn of the Cockspur Thorn, developed from the central of three axillary buds; one of the lateral buds is seen at its base.

bud or branch in its axil (as in the Barberry, Fig. 296), it must be of the nature of a leaf.

187. The Subterranean Modifications of the Stem are scarcely less numerous and diverse than the aerial; but they may all be reduced to a few principal types. They are perfectly distinguishable from roots by producing regular buds, or by being marked with scars, which indicate the former insertion of leaves, or furnished with scales, which are the rudiments or the vestiges of leaves. All the *Scaly roots* of the older botanists are therefore forms of the stem or branches, with which they accord in every essential respect. So, likewise, what are popularly called *Creeping roots* are really subterranean branches; such as those of the Mint, and of most Sedges and Grasses. Some of these, such as the *Carex arenaria* (Fig. 166) of



Europe, render important service in binding the shifting sands of the sea-shore. Others, like the Couch-Grass, are often very troublesome to the agriculturist, who finds it next to impossible to destroy them by the ordinary operations of husbandry; for, being furnished with buds and roots at every node, which are extremely tenacious of life, when torn in pieces by the plough, each fragment is only placed in the more favorable condition for becoming an independent plant. The Nut-Grass (*Cyperus Hydra*), an equally troublesome pest to the planters of Carolina and Georgia, is similarly constituted; and

FIG. 166. Creeping subterranean stem of *Carex arenaria*.

FIG. 167. Rhizoma of *Diphylleia cymosa*, showing six years' growth, and a bud for the seventh: *a*, the bud; *b*, base of the stalk of the current year; *c*, scar left by the decay of the annual stalk of the year before; and beyond are the scars of previous years.

besides, the interminable subterranean branches bear tubers, or reservoirs of nutritive matter, in their course, which have still greater powers of vitality, as they contain a copious store of food for the development of the buds they bear. The name of

188. *Rhizoma* or *Rootstock* is applied in a general way to all these perennial, horizontally elongated, more or less subterranean, root-



like forms of the stem; and more particularly to those that are considerably thickened by the accumulation of

starch or other forms of nutritive matter in their tissue, such as the so-called roots of Ginger, of the Iris or Flower-de-luce (Fig. 291), of the Calamus or Sweet Flag, and of the Blood-root. They grow after the manner of ordinary stems, advancing from year to year by the annual development of a bud at the apex, and emitting roots from the under side of the whole surface; thus established, the older portions die and decay, as corresponding additions are made to the opposite growing extremity. Each year's growth is often marked, as in some species of Iris (Fig. 291), by a narrowing at the place where the growth of the season is suspended, followed by an enlargement where it recommences; or else, as in the curious *Diphylleia* of the Alleghany Mountains (Fig. 167), and the *Polygonatum* or Solomon's Seal (Fig. 168), it is more indelibly stamped by an impressed circular scar (which has been likened to the impression of a seal), left annually, in autumn, by the death and separation from the perennial rootstock of the herbaceous stalk of the season which bore the foliage and blossoms. In *Diphylleia* the growth is so slow, and the ascending stems so thick, that the scars of successive years are



FIG. 168. Rootstock of *Polygonatum* or Solomon's Seal, with the terminal bud, the base of the stalk of the season, and three scars from which the latter has separated in as many former years.

FIG. 169. The short and upright rootstock of *Trillium erectum*, or Birthroot, with its terminal bud.

nearly in contact (Fig. 167). In the very short and slow-growing rootstock of *Trillium* (Fig. 169), the base of the leaf-bearing and flowering stem of the season surrounds and covers the terminal bud. In our common *Dentaria* or Toothwort, and in *Hydrophyllum*, the base of this annual stalk or of the leafstalks partakes in the thickening, and persists as a part of the rhizoma, in the form of fleshy scales or tooth-shaped processes. In other scaly rootstocks, these persistent bases of the leaves are thin, and more like bud-scales, and slowly decay after a year or two. All such markings are vestiges of leaves, &c., or the scars from which they have fallen or decayed away, and indicate the nodes. They show that the body that bears them belongs to the stem; and not to the root, which is wholly leafless. Root-stocks branch, just as other stems do, by the development of lateral buds from the axils of their scales or leaves. They serve as a reservoir of nourishing matter, for the maintenance of the annual growth, in the same manner as do thickened roots (145, 146). When such subterranean stems are thickened at the apex only, they produce

189. A Tuber. This is usually formed by the enlargement of the growing bud of a subterranean branch, and the deposition of starch,

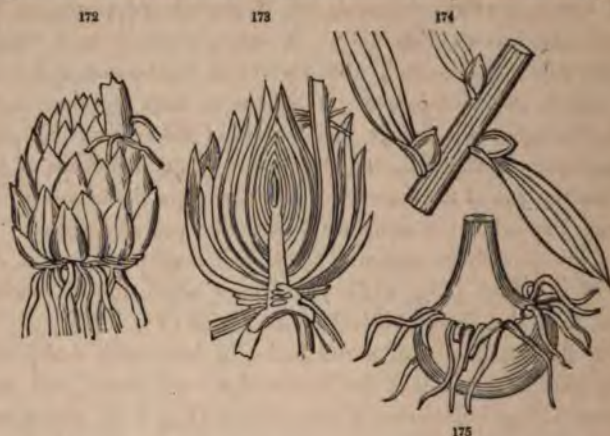


&c. in its tissue. This deposit serves for the nourishment of the buds (eyes) which it involves, when they develop the following year. The common Potato offers the most familiar example; and it is

FIG. 170. Base of the stem of the Jerusalem Artichoke (*Helianthus tuberosus*), with its tubers.

FIG. 171. A monstrous branch or bud of the Potato, above ground, showing a transition to the tuber. (From the Gardener's Chronicle.)

very evident on inspection of the growing plant, that the tubers belong to branches, and not to the roots. The nature of the potato



is also well shown by an accidental case (Fig. 171), in which some of the buds or branches above ground thickened and manifested a strong tendency to develop in the form of tubers. By heaping the soil around the stems, the number of tuberiferous branches is increased. The Jerusalem Artichoke also affords a familiar illustration of the tuber (Fig. 170). A tuber of a rounded form, and with few buds, or a rhizoma somewhat shorter and thicker than that in Fig. 169, effects a transition to

190. A *Corm* (*Cormus*), or *Solid Bulb*. This is a fleshy subterranean stem, of a rounded or oval figure and a compact texture; as in the Arum or Indian Turnip (Fig. 175), the Colchicum, the Crocus (Fig. 180, 181, 182), the Cyclamen,* &c. Corms have been termed *solid bulbs*. But the principal bulk of a true bulb consists not of stem but of leaves.



* The flattened corm of Cyclamen originates from the dilatation of the radicle itself. In the Turnip, Beet, and Radish (Fig. 138), this also enlarges with the proper root, the upper part of which accordingly partakes of the nature of the stem.

FIG. 172 The scaly bulb of a Lily. 173. A vertical section of the same, forming the annual stalk. 174. Axillary bulblets of *Lilium bulbiferum*. 175. Corm of *Arum triphyllum*.

FIG. 176. A radical leaf of the White Lily, with its base thickened into a bulb-scale, cut across below to show its thickness.

191. A **Bulb** is a permanently abbreviated stem, mostly shorter than broad, and clothed with scales, which are imperfect and thickened leaves, or more commonly the thickened and persistent bases of ordinary leaves (Fig. 176). In other words, it is a scaly and usually subterranean bud, with thickened scales, and a depressed axis which never elongates. Its centre or apex develops upward the herbaceous stalk, foliage, and flowers of the season, and beneath it emits roots. In the bulb, the thickening by the deposition of nutritive matter, stored for future use, takes place in the leaves or scales it bears, instead of the stem itself, as in the preceding forms. The scales are sometimes separate, thick, and narrow, as in the *Scaly bulb* of the Lily (Fig. 172); sometimes broad and in concentric layers, as in the *Tunicated bulb* of the Onion (Fig. 177).

192. **Bulblets** are small aerial bulbs, or buds with fleshy scales, which arise in the axils of the leaves of several plants, such as the common *Lilium bulbiferum* of the gardens (Fig. 174), and at length separate spontaneously, falling to the ground, where they strike root, and grow as independent plants. In the Onion, and other species of *Allium*, bulblets are often produced in place of flower-buds. These plainly show the identity of bulbs with buds.

193. All these extraordinary, no less than the ordinary, forms



- FIG. 177. Section of a tunicated bulb of the Onion.
 FIG. 178. Vertical section of the bulb of the Tulip, showing its stem (a) and buds (b, c).
 FIG. 179. Bulb of a Garlic, with a crop of young bulblets.
 FIG. 180. Vertical section of the corm of Crocus : a, new buds.
 FIG. 181. Vertical section of the corm of Colchicum, with the withered corm of the preceding (a), and the forming one (c) for the ensuing year.

of the stem, grow and branch, or multiply, by the development of terminal and axillary buds. This is perfectly evident in the rhizoma and tuber, and is equally the case in the corm and bulb. The stem of the bulb is usually reduced to a mere plate (Fig. 178, *a*), which produces roots from its lower surface, and leaves or scales from the upper surface. Besides the terminal bud (*c*), which usually forms the flower-stem, lateral buds (*b, b*) are produced in the axils of the leaves or scales. One or more of these may develop as flowering stems the next season, and thus the same bulb survive and blossom from year to year; or these axillary buds may themselves become bulbs, feeding on the parent bulb, which in this way is often consumed by its own offspring, as in the Garlic (Fig. 179); or, finally separating from the living parent, just as the bulblets of the Tiger Lily fall from the stem, they may form so many independent individuals.



So the corm of the Crocus (Fig. 182, 182^a) produces one or more new ones, which feed upon and exhaust it, and take its place; and the shrivelled remains of the old corm may be found underneath the new, the next season. The corm of Colchicum (Fig. 181) produces a new bud on one side at the base, and is consumed by it in the course of the season; the new one, after flowering by its terminal bud, is in turn consumed by its own offspring; and so on. In Fig. 181, we have at one view, *a*, the dead and shrivelled corm of the year preceding; *b*, that of the present season (a vertical section); and *c*, the nascent bud for the growth of the ensuing season.

Many of the forms which the stem assumes when above ground differ as much from the ordinary appearance as do any of these subterranean kinds, and, in fact, imitate their peculiarities; as, for example, the globular Melon-Cactus and Mamillaria, the columnar Cereus, and the jointed Opuntia or Prickly Pear. These are remarkably

194. Consolidated Forms of Vegetation. While ordinary plants are constructed on the plan of great expansion of surface, these are

FIG. 182. Corm of Crocus, the few thin enveloping scales removed, showing the shrivelled vestige of the last year's corm at the base, and buds developing into new ones on various parts of its surface. 182^a. Vertical section of a similar corm, with a terminal and one lateral bud.

formed on the plan of the least possible amount of surface in proportion to their bulk. A green rind serves the purpose of foliage; but the surface is as nothing compared with an ordinary leafy plant of the same amount of vegetable material. This consolidation is carried to the extreme in the Melon-Cactus, Mamillaria, and the like, of globular or corm-like shapes; their spherical figure being that which exposes the least possible part of the bulk to the air. Such plants are evidently adapted and designed for very *dry regions*; and in such only are they naturally found. Similarly, bulbous and corm-bearing plants, and the like, are a form of vegetation which in the growing season may in the foliage expand a large surface to the air and light, while during the period of rest the living vegetable is reduced to a globular or other form of the least surface; and this is protected by its outer coats of dead and dry scales, as well as by its subterranean situation; — thus exhibiting another and very similar adaptation to a season of drought. And such plants mainly belong to countries (such as Southern Africa, and parts of the interior of Oregon and California) which have a long hot season, during which little or no rain falls, when, their stalks and foliage above and their roots beneath being early cut off by drought, the plants rest securely in their compact bulbs, filled with nourishment, and retain their moisture with great tenacity, until the rainy season returns. Then they shoot forth leaves and flowers with wonderful rapidity, and what was perhaps a desert of arid sand becomes green with foliage and gay with blossoms, almost in a day. This will be more perfectly understood when the nature and the use of foliage shall have been more fully considered.

SECT. IV. THE INTERNAL STRUCTURE OF THE STEM IN GENERAL.

195. Having considered the various external forms and appearances which the stem exhibits, and its mode of increase in length, our attention may now be directed to its internal structure, and its mode of increase in diameter.

196. The stem embraces in its composition the various forms of elementary tissue that have already been described (Chap. I., Sect. II., III.); namely, ordinary cells, woody fibre, and vessels. At

first, indeed, it consists entirely of parenchyma (51), which possesses much less strength and tenacity than woody tissue, and is therefore inadequate to the purposes for which the stem, in all the higher plants, is destined. The stem of a Moss or a Liverwort is, in fact, composed of ordinary cellular tissue alone; and is therefore weak and brittle, well enough adapted to plants of humble size, but not for those which attain any considerable height. Accordingly, as soon as the stems of Phænogamous plants begin to grow, and in proportion as the leaves are developed, woody mingled with vascular tissue is introduced, to afford the requisite toughness and strength, and to facilitate the rise of the ascending sap. If the wood accumulates only to moderate extent in proportion to the parenchyma, the stem remains *herbaceous* (174); if it predominates and continues to accumulate from year to year, the proper woody trunk of a shrub or tree is formed.

197. The cellular part of the stem grows with equal readiness, in whatever direction the forces of vegetation act. It grows vertically, to increase the stem in length, and horizontally, to increase its diameter. Into this the elongated cells that form the woody tissue and ducts are introduced vertically; they run lengthwise through the stem and branches. Hence, the latter has been called the *longitudinal, vertical, or perpendicular system* (56, 64); and the cellular part, the *horizontal system* of the stem. Or the stem may be compared to a web of cloth; the cellular system forming the *woof*, and the woody, the *warp*.

198. The diversities in the internal structure of the stem are principally owing to the different modes in which the woody or vertical system is imbedded in the cellular. These diversities are reducible to two general plans; upon one or the other of which the stems of all Flowering plants are constructed. Not only is the difference in structure quite striking, especially in all stems more than a year old, but it is manifested in the whole vegetation of the two kinds of plants, and indicates the division of Phænogamous plants into two great classes, recognizable by every eye; which, in their fully developed forms, may be represented, one by the Oak and other trees of our climate, the other by the Palm (Fig. 184).

199. The difference between the two, as to the structure of their stems, is briefly and simply this. In the first, the woody system is deposited in *annual concentric layers* between a *central pith* and an *exterior bark*; so that a cross-section presents a series of rings or

circles of wood, surrounding each other and a distinct pith, and all surrounded by a separable bark. This is the plan, not only of the Oak, but of all the trees and shrubs of the colder climates. In the second, the woody system is not disposed in layers, but consists of separate bundles or threads of woody fibre, &c., running through the cellular system without apparent order; and presenting on the cross-section a view of the divided ends of these threads in the form of dots, diffused through the whole; but with no distinct pith, and no bark which is at any time readily separable from the wood. The appearance of such a stem, both on the longitudinal and the cross-section, is shown in Fig. 183; it may also be examined in the Cane or Rattan, the Bamboo, and in the annual stalk of Indian Corn or of Asparagus. That of ordinary wood of the first sort is too familiar to need a pictorial illustration.

200. *Exogenous Structure.* The stem, in the first case, increases in diameter by the annual formation of a new layer of wood, which is deposited between the preceding layer and the bark; that is, the wood increases by annual additions to its outside. Hence, such stems are said to be *EXOGENOUS*; and plants whose stems grow in this way are called *EXOGENOUS PLANTS*, or briefly *EXOGENS*; that is, as the term literally signifies, *outside-growers*.

201. *Endogenous Structure.* In the second case, the new woody matter is intermingled with the old, or deposited towards the centre, which becomes more and more occupied with the woody threads as the stem grows older; and increase in diameter, so far as it depends on the formation of new wood, generally takes place by the gradual distention of the whole. Accordingly, these stems are said to exhibit the *ENDOGENOUS* structure or growth; and such plants are called *ENDOGENOUS PLANTS*, or *ENDOGENS*; literally, *inside-growers*.



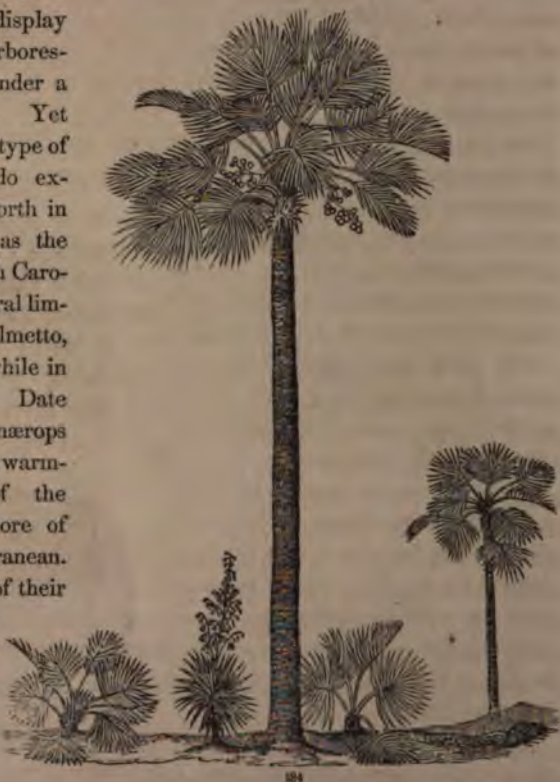
202. The two great classes of *Phænogamous* plants, indicated by this difference in the stem, are distinguishable even in the embryo state, by differences quite as marked as those which prevail in their whole port and aspect. The embryo of all plants that have endogenous stems bears only a single cotyledon; hence, Endogens are also called *MONOCOTYLEDONOUS PLANTS* (128). The embryo of

FIG. 183. Section (longitudinal and transverse) of a Palm-stem.

plants with exogenous stems bears a pair of cotyledons and unfolds a pair of seed-leaves in germination (Fig. 106, 125); hence, Exogens are likewise called DICOTYLEDONOUS PLANTS.

SECT. V. THE ENDOGENOUS OR MONOCOTYLEDONOUS STEM.

203. ENDOGENS, or *Inside-growers*, although they have many humble representatives in Northern climes, yet only attain their full characteristic development, and display their noble arborescent forms, under a tropical sun. Yet Palms — the type of the class — do extend as far north in this country as the coast of North Carolina (the natural limit of the Palmetto, Fig. 184); while in Europe the Date and the *Chamærops* thrive in the warmer parts of the European shore of the Mediterranean. The manner of their growth gives them a striking appearance; their trunks being unbranched,



cylindrical columns, rising majestically to the height of from thirty to one hundred and fifty feet, and crowned at the summit with a simple cluster of peculiar foliage. Their internal structure is equally different from that of ordinary wood.

FIG. 184. The *Chamærops* Palmetto, in various stages, and the *Yucca Draconis*.

204. The stem of an Endogen, as already explained (199), offers no manifest distinction into bark, pith, and wood; and the latter is not composed of concentric rings or layers. But it consists of bundles of woody and vascular tissue, in the form of fibres or threads, which are imbedded, with little apparent regularity, in cellular tissue; and the whole is enclosed in an integument, which does not strictly resemble the bark of an Exogenous plant, inasmuch as it does not increase by layers, and is never separable from the wood. The fibrous bundles which compose the wood, and which consist of a mass of woody fibres surrounding several vessels, are distributed throughout the cellular system of the stem, but most abundantly towards the circumference. Each bundle usually contains all the elements of the wood of the exogenous stem; namely, vessels, proper woody tissue, and bast-cells. The bundles often may be traced directly from the base of the leaves down through the stem, some of them to the roots in a young plant, while others, curving outwards, lose themselves in the cortical integument, or rind. As the stem increases, new bundles, springing from the bases of more recently developed leaves, are at first directed towards the centre of the stem, along which they descend for some distance, growing more slender in their course, and then, curving outwards, mostly terminate in the rind. It is partly in consequence of the cohesion of these obliquely descending fibres to the false bark, that the latter cannot, as in Exogens, be separated from the wood beneath. The manner in which the woody threads are consequently interwoven is shown in Fig. 185. The Palm-like *Yuccas* of the Southern States offer beautiful illustrations of the kind.



185

205. Endogenous stems, instead of having the oldest and hardest wood at the centre and the newest and softest at the circumference, as in ordinary trees, are softest towards the centre and most compact at the circumference. They increase in diameter with the increasing number of woody bundles (which multiply as new leaves are

FIG. 185. Vertical and transverse section of a young endogenous stem, showing the curving of the fibres.

produced), as long as the rind is capable of distention. In some instances, as in the arborescent *Yuccas* and the *Dracænas* or Dragon-trees, the rind remains soft and capable of unlimited growth; but in the Palms, and in most woody Endogens, it soon indurates, and the stem consequently increases no further in diameter. The wood of the lower part of such stem is more compact than the upper, being more filled with woody bundles, and the rind is firmer, from the greater number of ligneous fibres which terminate in it, and from its proper induration.

206. Palms generally grow from the terminal bud alone, and perish if this bud be destroyed; they grow slowly, and bear their foliage in a cluster at the summit of the trunk, which consequently forms a simple cylindrical column. But in some instances two or more buds develop, and the stem branches, as in the Doum Palm of Upper Egypt, and in the Pandanus, or Screw-Pine (Fig. 140), which belongs to a family allied to Palms: in such cases the branches are cylindrical. But when lateral buds are freely developed (as in the Asparagus), or the leaves are scattered along the stem or branches (as in the Bamboo, Maize, &c.), these taper upwards, just as in Exogens. A particular comparison of the structure and growth of the Endogenous stem with the Exogenous cannot be instituted until the latter is explained in detail.

SECT. VI. THE EXOGENOUS OR DICOTYLEDONOUS STEM.

207. SINCE the Exogenous class is by far the larger in every part of the world, and embraces all the trees and shrubs with which we are familiar in the cooler climates, the structure of this kind of stem demands more detailed notice. To obtain a true and clear idea of its internal structure, we should commence at its origin and follow the course of development.

208. In the embryo, or at least at some period antecedent to germination, the rudimentary stem is entirely composed of parenchyma. But as soon as it begins to grow, some of the cells begin to lengthen into tubes, to be marked with transverse bars or spiral lines, and thus give rise to *ducts* or *vessels* (57-60); these form a small and definite number of bundles or threads, say four equidistant ones in the first instance, as in the Sugar Maple: surrounding these, other slender cells of smaller calibre, and destitute of markings,

soon appear, and form the earliest woody tissue. As the rudiments of the next internode and its leaves appear, two or four additional threads of vascular tissue appear in the stem below, in the parenchyma between the earliest ones, and are equally surrounded with forming woody tissue. At an early stage, therefore, the developing stem is seen to be traversed by several bundles of woody tissue, with some vessels imbedded; and these, as they increase and enlarge, run together so as to make up a woody zone (or, as seen in the cross-section, a ring), enclosing the central part of the parenchyma within it, and itself enclosed by the external parenchyma. Thus a zone or layer of wood is formed, which is so situated in the original homogeneous cellular system as to divide it into two parts; namely, a central portion, which forms the pith, and an exterior portion, which belongs to the bark. The whole is of course invested by the skin or epidermis, which covers the entire surface of the plant. The way in which the layer of wood thus originates is somewhat rudely illustrated by the annexed diagrams (Fig. 186-188). The several



woody masses, or wedges, are separated from each other by lines or bands of the original cellular tissue, which pass from the pith to the bark, and which necessarily become narrower and more numerous as the woody bundles or wedges increase in size and number. These bands are the

209. Medullary Rays. These form the radiating lines that the cross-section of most exogenous wood so plainly exhibits, especially that of the Oak, Plane, &c. They consist of parenchyma, more

FIG. 186. Plan of a cross-section of a forming seedling stem, showing the manner in which the young wood is imbedded in the cellular system.

FIG. 187. The same at a later period, the woody bundles increased so as nearly to fill the circle.

FIG. 188. The same at the close of the season, where the wood has formed a complete circle, separating the pith from the bark, except that they are still connected by narrow portions of the cellular system (the *medullary rays*) which radiate from the pith to the bark.

or less flattened by the pressure of the woody wedges, and they serve to keep up the communication between the pith and the bark.

210. The First Year's Growth of an exogenous stem accordingly consists of three principal parts, viz.: 1st, a central cellular portion, or *Pith*; 2d, a zone of *Wood*; and 3d, an exterior cellular portion, or

Bark. These several parts are displayed in Fig. 189–191, as they occur in a woody stem a year old.

211. The Pith (*Medulla*) consists entirely of soft cellular tissue, or parenchyma* (51), which is at first gorged with sap. Many stems expand so rapidly in diameter during their early growth, that they become hollow, the pith being torn away by the distention, and its remains forming a mere lining to the cavity. In the Walnut and the Poke (*Phytolac-*



* In rare instances a few threads of woody tissue and vessels are found dispersed through the pith, presenting a somewhat remarkable anomaly. This occurs in *Aralia racemosa*, and more strikingly in *Oxybaphus*, *Mirabilis* or *Four-o'clock*, and other *Nyctaginaceæ*.

FIG. 189. Longitudinal and transverse section of a stem of the Soft Maple (*Acer dasycarpum*), at the close of the first year's growth; of the natural size.

FIG. 190. Portion of the same, magnified, showing the cellular pith, surrounded by the wood, and that enclosed by the bark.

FIG. 191. More magnified slice of the same, reaching from the bark to the pith: *a*, part of the pith; *b*, vessels of the medullary sheath; *c*, the wood; *dd*, dotted ducts in the wood; *ee*, annular ducts; *f*, the liber, or inner fibrous bark; *g*, the cellular envelope, or green bark; *h*, the corky envelope; *i*, the skin or epidermis; *k*, one of the medullary rays, seen on the transverse section.

ca) it is early separated into a series of horizontal plates. As the stem grows older the pith becomes dry and light, its cells filled with air only; and then it is of no further use to the plant.

212. The Wood consists of proper woody tissue (53), among which the vascular is more or less copiously mingled, principally in the form of dotted ducts (Fig. 191, *d*), or occasionally some annular ducts (*e*), &c. The dotted ducts are of so considerable calibre, that they are conspicuous to the naked eye in many ordinary kinds of wood, especially where they are accumulated in the inner portion of each layer, as in the Chestnut and Oak. In the Maple, Plane, &c., they are rather equably scattered through the annual layer, and are of a size so small, that they are not distinguishable by the naked eye. — Next the pith, i. e. in the very earliest formed part of the wood, some spiral ducts are uniformly found (Fig. 191, *b*), and this is the only part of the exogenous stem in which these ordinarily occur. They may be detected by breaking a woody twig in two, after dividing the bark and most of the wood by a circular incision, and then pulling the ends gently asunder, when their spirally coiled fibres are readily drawn out as gossamer threads. As these spiral ducts form a circle immediately surrounding the pith, they form what has been termed the MEDULLARY SHEATH. This is no special organ, and hardly requires a special name, since it merely represents the earliest-formed vascular tissue of the stem.

213. The vertical section in Fig. 191 divides one of the woody wedges; and therefore the medullary rays do not appear. But in

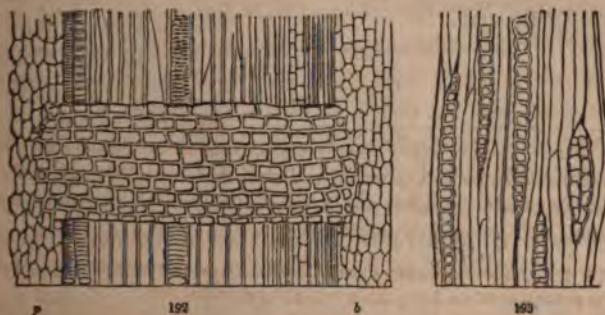


FIG. 192. Vertical section through the wood of a branch of the Maple, a year old; so as to show one of the medullary rays, passing transversely from the pith (*p*) to the bark (*b*): magnified. But a section can seldom be made so as to show one unbroken plate stretching across the wood, as in this instance.

FIG. 193. A vertical section across the ends of the medullary rays; magnified.

the much more magnified Fig. 192, the section is made so as to show the surface of one of these plates, and one of the MEDULLARY RAYS passing horizontally across it, connecting the pith (*p*) with the bark (*b*). These medullary rays form the *silver-grain*, (as it is termed,) which is so conspicuous in the Maple, Oak, &c., and which gives the glimmering lustre to many kinds of wood when cut in this direction. But a section made as a tangent to the circumference, and therefore perpendicular to the medullary rays, brings their ends to view, as in Fig. 193; much as they appear when seen on the surface of a piece of wood from which the bark is stripped. They are here seen to be composed of parenchyma, and to represent the horizontal system of the wood, or the *woof*, into which the vertical woody fibre, &c., or *warp*, is interwoven. The inspection of a piece of oak or maple wood at once shows the pertinency of this illustration.

214. The Bark, in a stem of a year old, must next be considered. At first it consists of simple parenchyma, undistinguishable from that of the pith, except that it assumes a green color when exposed to the light, from the production of *chlorophyll* (92) in its cells. But during the formation of the wood of the season, an analogous formation occurs in the bark. The inner portion, next the wood, has woody tissue formed in it, and becomes

215. The Liber, or *Inner Bark* (Fig. 191, *f*). The fibre-like cells, which give to the inner bark of those plants that largely contain them its principal strength and toughness, are of the kind already described under the name of *bast-cells* or *bast-tissue* (55). They are remarkable for their length, flexibility, and the great thickness of their walls. They form in bundles, or in bands separated by extensions of the medullary rays, one accordingly corresponding to each of the woody plates or wedges; or sometimes (as in *Negundo*, Fig. 194, 195) they are confluent into an unbroken circle round the whole circumference. Complete and well-developed liber, like that of the Basswood, consists of three elements, viz.: 1. bast-cells or fibres; 2. large and more or less elongated cells, with thinner walls variously marked with transparent spots, appearing like perforations, and usually traversed by an exceedingly minute net-work; and 3. cells of parenchyma. The liber has received the technical name of ENDOPHLEUM (literally *inner bark*). In most woody stems the exterior part of the bark, in which no woody tissue occurs, is early distinguishable into two parts, an inner and an outer. The former is

216. The Cellular Envelope, or *Green Layer* (Fig. 191, *g*), also called, from its intermediate position, the *MESOPHLEUM*. This is composed of loose parenchyma, with thin walls, much like the green pulp of leaves, and containing an equal abundance of chlorophyll. It is the only part of the bark that retains a green color. In woody stems this is soon covered with

217. The Corky Envelope, or *EPIPHLEUM* (Fig. 191, *b*), which gives to the twigs of trees and shrubs the hue peculiar to each species, generally some shade of ash-color or brown, or occasionally of much more vivid tints. It is this tissue, which, taking an unusual development, forms the *cork* of the Cork-Oak, and those corky expansions of the bark which are so conspicuous on the branches of

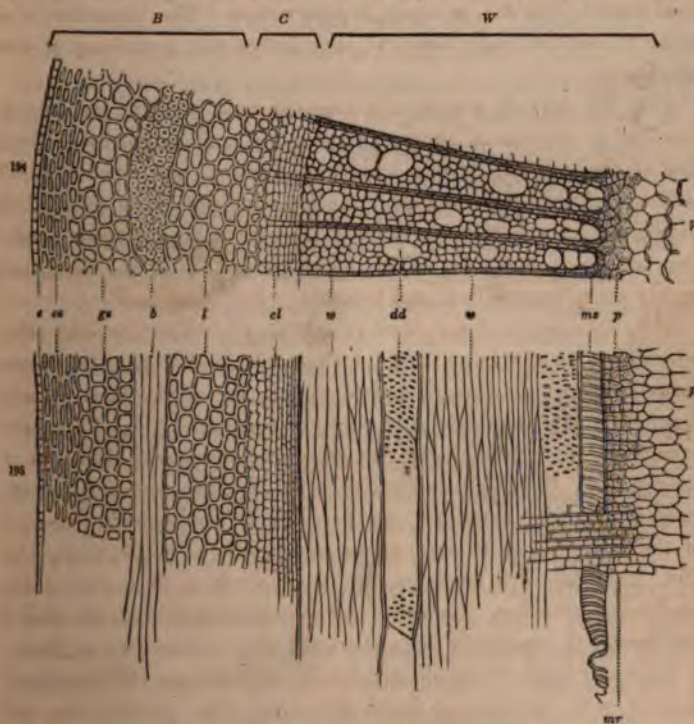


FIG. 194. Portion of a transverse section, and 195, a corresponding vertical section, magnified, reaching from the pith, *p*, to the epidermis, *e*, of a stem of *Negundo*, a year old: *B*, the bark; *W*, the wood; and *C*, the cambium-layer, as found in February. The references are in the text above; except *ms*, portion of a medullary ray, seen on the vertical section, where it runs into the pith: *dd*, dotted ducts: *cl*, the inner part of the cambium-layer, which begins the new layer of wood. In this tree, we find a thick layer of parenchyma (*l*) inside of the bast-tissue, and therefore belonging to the liber. No bast-tissue is formed in it the second year.

the Sweet Gum (*Liquidambar*), and on some of our Elms (*Ulmus alata* and *racemosa*). It also forms the paper-like, exfoliating layers of Birch-bark. It is composed of laterally flattened parenchymatous cells, much like those of the EPIDERMIS (69, Fig. 191, *i*), which directly overlies it, and forms the skin or surface of the stem.

218. The elements of an exogenous stem of a year old, especially in a woody plant, accordingly are these, proceeding from the centre towards the circumference:—

I. In the Wood:

1. The *Pith*, belonging to the cellular system (Fig. 194, 195, *p*).
2. The *Medullary Sheath*, *ms*, } which belong to the woody or
3. The *Layer of Wood*, *W, w*, } longitudinal system.
4. The *Medullary Rays*, *mr*, a part of the cellular system.

II. In the Bark:

5. The *Liber*, *l*; its bast-tissue, *b*, belongs to the woody system.
6. The *Outer Bark*, belonging wholly to the cellular system, and composed of two parts, viz.: 1st, the *Green* or *Cellular Envelope*, *ge*, and 2d, the *Corky Envelope*, *ce*.
7. The *Epidermis*, *e*, or skin, which invests the whole.

219. An herbaceous stem does not essentially differ from a woody one of this age, except that the wood forms a less compact or thinner zone; and the whole perishes, at least down to the ground, at the close of the season. But a woody stem makes provision for continuing its growth the second year. As the layer of wood continues to increase in thickness throughout the season, by the multiplication of cells on its outer surface, between it and the bark, and when growth ceases this process of cell-multiplication is merely suspended, so there is always a zone of delicate young cells interposed between the wood and the bark. This is called the

220. *Cambium-Layer*, (Fig. 194, 195, *C*). It is charged with organizable matter (protoplasm, dextrine, &c.) in the form of a mucilage, which is particularly abundant in the spring when growth recommences. This mucilaginous matter was named *Cambium* by the older botanists; who supposed—as is still generally thought—that the bark, then so readily separable; really separated from the wood in spring, that a quantity of rich mucilaginous sap was poured out between them, and that this sap, or cambium, was organized into a tissue, the inner part becoming new wood, the outer, new bark. But delicate slices will show that there is then no more interruption of the wood and inner bark than at any other season; that

the two are always organically connected by an extremely delicate tissue of young and vitally active cells, just in the state in which they multiply by division (33). The bark, indeed, is very readily detached from the wood in spring, because the cambium-layer is then gorged with sap; but the separation is effected by the rending of a delicate forming tissue. And if some of this apparant mucilage be scraped off from the surface of the wood, and examined under a good microscope, it will be seen to be a thin stratum of young wood-cells, with the ends of medullary rays here and there interspersed, and appearing much as in Fig. 193, only the young wood-cells are mostly shorter. The inner portion of the cambium-layer is therefore nascent wood, and the outer is nascent bark. And it is by the growth of the cambium-layer, renewed year after year, that the

221. Annual Increase of the Wood of Exogenous plants is effected. As the cells of this layer multiply, the greater number lengthen vertically into prosenchyma or woody tissue; while some are transformed into ducts, and others, remaining as parenchyma, continue the medullary rays or commence new ones. In this way a second layer of wood is formed the second season, over the whole surface of the former layer and between it and the bark, and continuous with the woody layer of the new roots below and of the leafy shoots of the season above. Each succeeding year another layer is added to the wood in the same manner, coincident with the growth in length by the development of the buds. A cross-section of an exogenous stem, therefore, exhibits the wood disposed in concentric rings between the bark and the pith; the oldest lying next the latter, and the youngest occupying the circumference. Each layer being the product of a single year's growth, the age of an exogenous tree may, in general, be correctly ascertained by counting the rings in a cross-section of the trunk.*

* The annual layers are most distinct in trees of temperate climates like ours, where there is a prolonged period of total repose, from the winter's cold, followed by a vigorous resumption of vegetation in spring. In tropical trees they are rarely so well defined; but even in these there is generally a more or less marked annual suspension of vegetation, occurring, however, in the dry and hotter, rather than in the cooler season. There are numerous cases, moreover, in which the wood forms a uniform stratum, whatever be the age of the trunk, as in the arborescent species of Cactus; or where the layers are few and by no means corresponding with the age of the trunk, as in the Cycas.

In many woody climbing or twining stems, such as those of Clematis, Aristo-

222. The Limitation of the Annual Layers results from two or more causes, separate or combined. In oak and chestnut wood, and the like, the layers are strongly defined by reason of the accumulation of the large dotted ducts, here of extreme size and in great abundance, in the inner portion of each layer, where their open mouths on the cross-section are conspicuous to the naked eye, making a strong contrast between the inner porous, and the exterior solid part of the successive layers. In Maple and Beech wood, however, the ducts are smaller, and are dispersed throughout the whole breadth of the layer; and in coniferous wood, viz. that of Pine, Cypress, &c., there are no ducts at all, but only a uniform woody tissue of a peculiar sort (46, 54). Here the demarcation between two layers is owing to the greater fineness of the wood-cells formed at the close of the season, viz. those at the outer border of the layer, while the next layer begins, in its vigorous vernal growth, with much larger cells, thus marking an abrupt transition from one layer to the next. Besides being finer, the last wood-cells of the season are often flattened laterally, more or less.

223. Each layer of wood, once formed, remains unchanged in position and dimensions. But in trunks of considerable age, the older layers generally undergo more or less change in color and density, distinguishing the wood into two parts, viz.

224. Sap-wood and Heart-wood. In the germinating plantlet and in the developing bud, the sap ascends through the whole tissue, of whatever sort; at first through the parenchyma, for there is then no other tissue; and the transmission is continued through it, especially through its central portion, or the pith, in the growing apex of the stem throughout. But in the older parts below, the pith, soon drained of sap, becomes filled with air in its place, and thenceforth it bears no part in the plant's nourishment. As soon as wood-cells and ducts are formed, they take an active part in the conveyance of sap;

lochias Siphon, and *Menispermum Canadense*, the annual layers are rather obscurely marked, while the medullary rays are unusually broad; and the wood therefore forms a series of separable wedges disposed in a circle around the pith. In the stem of one of our Trumpet-creepers (the *Bignonia capreolata*) the annual rings, after the first four or five, are interrupted in four places, and here as many broad plates of cellular tissue, belonging properly to the bark, are interposed, passing at right angles to each other from the circumference towards the centre, so that the transverse section of the wood nearly resembles a Maltese cross. But these are all exceptional cases, which scarcely require notice in a general view.

for which their tubular and capillary character is especially adapted. But the ducts in older parts, except when gorged with sap, contain air alone; and in woody trunks the sap continues to rise year after year, to the places where growth is going on, mainly through the proper woody tissue of the wood. In this transmission the new layers are most active, and these are in direct communication with the new roots on the one hand and with the buds or shoots and leaves of the season on the other. So, by the formation of new annual layers outside of them, the older ones are each year removed a step farther from the region of growth; or rather the growing stratum, which connects the fresh rootlets that imbibe with the foliage that elaborates the sap, is each year removed farther from them. The latter, therefore, after a few years, cease to convey sap, as they have long

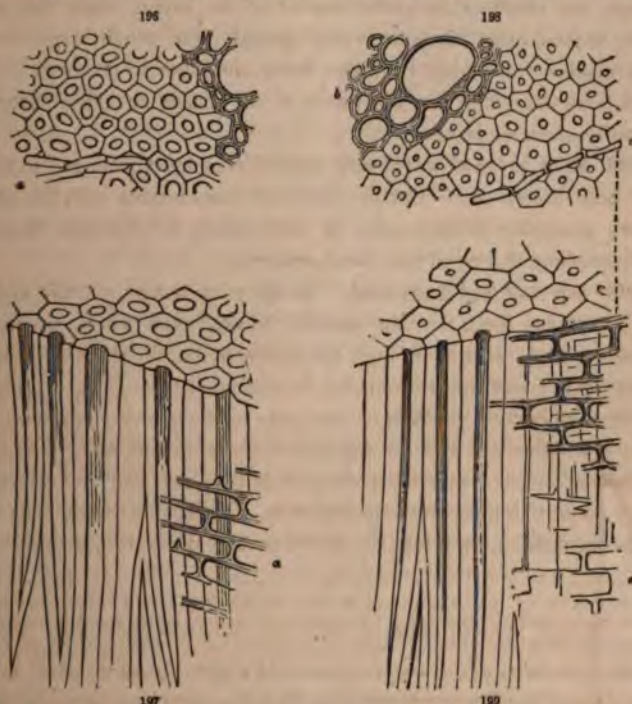


FIG. 196. Magnified cross-section of a portion of woody tissue of White Oak, a year old. 197. A longitudinal as well as cross section of the same, a little higher magnified. *a, a*, Portions of one of the smaller medullary rays.

FIG. 198. Magnified cross-section of woody tissue from the same stem, taken from a layer of heart-wood, 24 years old: *b*, ducts; *a*, portion of one of the minuter medullary rays. 199. Combined cross and longitudinal section of the same: *a*, tissue of a medullary ray.

before ceased to take part in any vital operations. The cells of the older layer, also, commonly have thicker walls and smaller calibre than those of the newer, — as here shown in Fig. 198, 199, compared with Fig. 196, 197, — owing to the greater amount of thickening organic materials (43) mingled with encrusting mineral matters introduced with the water imbibed by the roots (93) which have been deposited upon them from within. This older, more solidified, and harder wood, which occupies the centre of the trunk, and is the part principally valuable for timber, &c., is called **HEART-WOOD**, or **DURAMEN**: while the newer layers of softer, more open, and bibulous wood, more or less charged with sap, receive the name of **SAP-WOOD**, or **ALBURNUM**. The latter name was given by the earlier physiologists in allusion to its white or pale color. In all trees which have the distinction between the sap-wood and heart-wood well marked, the latter acquires a deeper color, and that peculiar to the species, such as the dark brown of the Black Walnut, the blacker color of the Ebony, the purplish-red of Red Cedar, and the bright yellow of the Barberry. These colors are owing to special vegetable products mixed with the incrusting matters; but sometimes the hue appears to be rather an alteration of the lignine with age. In the Red Cedar, the deep color belongs chiefly to the medullary rays. In many of the softer woods, there is little thickening of the cell-walls, and little change in color of the heart-wood, except from incipient decay, as in the White Pine, Poplar, Tulip-tree, &c. The heart-wood is no longer in any sense a living part; it may perish, as it frequently does, without affecting the life or health of the tree.

225. **The Bark** is much more various in structure and growth than the wood: it is also subject to grave alterations with advancing age, on account of its external position, viz. to distention from the constantly increasing diameter of the stem within, and to abrasion and decay from the influence of the elements without. It is never entire, therefore, on the trunks of large trees; but the dead exterior parts, no longer able to enlarge with the enlarging wood, are gradually fissured and torn, and crack off in layers, or fall away by slow decay. So that the bark of old trunks bears but a small proportion in thickness to the wood, even when it makes an equal amount of annual growth.

226. The three parts of the bark (214–217), for the most part readily distinguishable in the bark of young shoots, grow independently, each by the addition of new cells to its inner face, so long as

It grows at all. The green layer does not increase at all after the first year; the opaque corky layer soon excludes it from the light; and it gradually perishes, never to be renewed. The corky layer commonly increases for a few years only, by the formation of new tabular cells: occasionally it takes a remarkable development, forming the substance called *Cork*, as in the Cork Oak. A similar growth occurs on the bark of several species of Elm, of our Liquidambar or Sweet-Gum, &c., producing thick corky plates on the branches. In the White and Paper Birch, thin layers, of a very durable nature, are formed for a great number of years; each layer of tabular and firmly coherent cells (Fig. 200, *a*) alternates with a thinner stratum of delicate, somewhat cubical and less compact cells (*b*), which break up into a fine powder when disturbed, and allow the thin, paper-like plates to exfoliate.



227. The liber, or inner bark (215), continues to grow throughout the life of the tree, by an annual addition from the cambium-layer applied to its inner surface. Sometimes the growth is plainly distinguishable into layers, corresponding with or more numerous than the annual layers of the wood: often, there is scarcely any trace of such layers to be discerned. In composition and appearance the liber varies greatly in different plants,* especially in trees and shrubs. That of Bass-wood or Linden, and of other plants with a similar fibrous bark, may be taken as best representing the liber. Here it consists of strata of very thick-walled cells alternating with thin-walled cells. The thick-walled cells are bast-cells (55, Fig. 49, 53), are much elongated vertically, and form the fibrous portion of

* The best account of the liber that has yet been given is that by Mohl, in the *Botanische Zeitung*, Vol. 13, p. 873 (1855), of which a French translation is published in the *Annales des Sciences Naturelles*, ser. 4, Vol. 5, p. 141, et seq. (1856).

FIG. 200. Transverse section of a minute portion of White Birch bark, the corky layer highly magnified: *a*, the firm, tabular cells, *b*, delicate thin-walled cells which separate the papery plates. (After Link.)

the bark. The thin-walled cells are those of ordinary parenchyma, mingled, at the inner part of each stratum, with larger and longer ones, marked (on some sides at least) with the thin and reticulated spots or punctuations already described (215). These last may be termed the *proper cells of the liber*, as they are peculiar to this part of the bark, are seldom if ever absent, they contain an abundance of mucilage and proteine, and in all probability they take the principal part in the descending circulation of the plant, if it may so be called, i. e. in conveying downwards and distributing the rich sap which has been elaborated in the foliage. It is evident that the bast-cells, which in Linden (Fig. 53) are seen to be almost solid, are not adapted to this purpose.

228. That bast-cells are not an essential part, is further evident from the fact, that they are altogether wanting in the bark of some plants, and are not produced after the first year in many others. The latter is the case in Negundo, where abundant bast-cells, like those of Bass-wood, compose the exterior portion of the first year's liber (Fig. 194, 195, *b*), but none whatever is formed in the subsequent layers. In Beeches and Birches, also, a few bast-cells are produced the first year, but none afterwards. In Maples a few are formed in succeeding years. In the Pear bast-cells are annually formed, but in very small quantity, compared with the parenchymatous part of the liber. In Pines, at least in White Pines, the bark is nearly as homogeneous as the wood, the whole liber, except what answers to the medullary rays, consisting of one kind of cells, resembling those

of bast or of wood in form, but agreeing with the proper liber-cells in their structure and markings. Although the liber of Birch produces no bast-cells after the first year, it abounds in short cells equally solidified by internal deposition, and of a gritty texture, which might be mistaken for bast-cells on the cross-section (Fig.



201

201). A longitudinal section discloses the difference.

229. The bark on old stems is constantly decaying or falling away from the surface, without any injury to the tree; just as the heart-wood may equally decay within without harm, except by mechani-

FIG. 201. Cross-section of a cluster of solidified and indurated cells from the liber of the White Birch. (After Link.)

cally impairing the strength of the trunk. Great differences are observable as to the time and manner in which the older bark of different shrubs and trees is thrown off, according to the structure in each species. Some trees and shrubs have their trunks invested with the liber of many years' growth, although only the innermost layers are alive; in others it scales off much earlier. On the stems of the common Honeysuckle, of the Nine-Bark (*Spiræa opulifolia*), and of Grape-vines (except of our Muscadine Grape), the liber lives only one season, and is detached the following year, hanging loose in papery layers in the former species, and in fibrous shreds in the latter.

230. While the newer layers of the wood abound in crude sap, which they convey to the leaves (224), those of the inner bark abound in elaborated sap (79, 227), which they receive from the leaves and convey to the cambium-layer or zone of growth. The proper juices and peculiar products of plants (88) are accordingly found in the foliage and the bark, especially in the latter. In the bark, therefore, (either of the stem or of the root,) medicinal and other principles are usually to be sought, rather than in the wood. Nevertheless, as the wood is kept in connection with the bark by the medullary rays, many products which probably originate in the former are deposited in the wood.

231. *The Living Parts of a Tree or Shrub*, of the Exogenous kind, are obviously only these:—1st. The summit of the stem and branches, with the buds which continue them upwards and annually develop the foliage. 2d. The fresh tips of the roots and rootlets annually developed at the opposite extremity. 3d. The newest strata of wood and bark, and especially the interposed cambium-layer, which, annually renewed, maintain a living communication between the rootlets on the one hand and the buds and foliage on the other, however distant they at length may be. These are all that is concerned in the life and growth of the tree; and these are annually renewed. The branches of each year's growth are, therefore, kept in fresh communication, by means of the newer layers of wood, with the fresh rootlets, which are alone active in absorbing the crude food of the plant from the soil. The fluid they absorb is thus conveyed directly to the branches of the season, which alone develop leaves to digest it. And the sap they receive, having been elaborated and converted into organic nourishing matter, is partly expended in the upward growth of new branches, and partly in the formation of a new layer

of wood, reaching from the highest leaves to the remotest rootlets.* As the exogenous tree, therefore, annually renews its buds and

* The layers of wood and bark, by which the exogenous stem annually increases in diameter, are formed by the multiplication of the cells of the cambium-layer throughout its whole extent. That the organic material to supply this growth in ordinary vegetation descends in the bark, for the most part, and that the order of growth in the formation of wood is from above downwards, and also the general dependence of this growth upon the action of the foliage, may be inferred from a variety of facts and considerations. The connection of the wood with the leaves is shown :—(1.) By tracing the threads of soft woody Endogens, such as Yucca, directly from the base of the leaf into the stem, and thence downward to their termination, towards which they become attenuated, lose their vessels, and are finally reduced to slender shreds of woody tissue. (2.) The amount of wood formed in a stem or branch, other things being equal, is in a relation to the number and size of the leaves it bears ; its amount in any portion of the branch is in direct proportion to the number of leaves above that portion. Thus, when the leaves are distributed along a branch, it tapers to the summit, as in a common Reed or a stalk of Indian Corn ; when they grow in a cluster at the apex, it remains cylindrical, as in a Palm (Fig. 184). Consequently the increase of the trunk in diameter directly corresponds with the number and vigor of the branches. The greater the development of vigorous branches on a particular side of a tree, the more wood is formed, and the greater the thickness of the annual layers on that side of the trunk. (3.) In a seedling, the wood appears in proportion as the leaves are developed. (4.) If a young branch be cut off just below a node (156), so as to leave an internode without leaves or bud, little or no increase in diameter will ordinarily take place down to the first leaf below. But if a bud be inserted into this naked internode, as the bud develops, increase in diameter, with the formation of new wood, recommences. That the formation proceeds from above downwards, or that the elaborated sap which furnishes the material for the growth is diffused from above downwards, appears from the effect of a ligature around exogenous stems, or of removing a ring of bark. It is a familiar fact, that, when a ligature is closely bound around a growing exogenous stem, the part above the ligature swells, and that below does not. Every one may have observed the distortions that twining stems thus accidentally produce upon woody exogenous trunks, causing an enlargement on the upper side of the obstruction. When the stem is girdled, by removing a ring of bark so as completely to expose the surface of the wood, the part above the ring enlarges in the same manner ; that below does not, until the incision is healed. The wood of the roots is manifestly formed in a descending direction. But this is continuous with that of the stem ; and its first layer, the extension of the wood of the radicle into the primary root, agrees in composition with the wood of the succeeding layers in the stem, having no spiral vessels, but only ducts. Still, whatever analogy there may be between the growth of the wood in the stem and of roots, there is no real basis for the ingenious conception of Thonars and of Gaudichaud, that wood is the roots of buds or leaves, or that it is absolutely dependent upon them for its formation.

leaves, its wood, bark, and roots, — everything, indeed, that is concerned in its life and growth, — there seems to be no reason, no necessary cause inherent in the tree itself, why it may not live indefinitely. Accordingly, some trees are known to have lived for twelve hundred years or more; and others now survive which are probably above two thousand years old, and perhaps much older.* This longevity ceases to be at all surprising when we consider, that, although the tree or herb is in a certain sense an *individual*, yet it is not an individual in the sense that a man or any ordinary animal is. Viewed philosophically,

232. The Plant is a Composite Being, or community, lasting, in the case of a tree especially, through an indefinite and often immense number of generations. These are successively produced, enjoy a term of existence, and perish in their turn. Life passes onward continually from the older to the newer parts, and death follows, with equal step, at a narrow interval. No portion of the tree is now living that was alive a few years ago; the leaves die annually and are cast off, while the internodes or joints of stem that bore them, as to their wood at least, buried deep in the trunk, under the wood of succeeding generations, are converted into lifeless heart-wood, or perchance decayed, while the bark that belonged to them is thrown off from the surface. It is the aggregate, the blended mass alone, that long survives. Plants of single cells, and of a definite form, alone exhibit complete individuality; and their existence is extremely brief. The more complex vegetable of a higher grade is not to be compared with the animal of the highest organization, where the offspring always separates from the parent, and the individual is simple and indivisible. But it is truly similar to the branching or arborescent coral, or to other compound animals of the lowest grade, where successive generations, though capable of living independently and sometimes separating spontaneously, yet are usually developed in connection, blended in a general body, and nourished more or less in common. Thus the coral structure is built up by the combined labors of a vast number of individuals, — by the suc-

* The subject of the longevity of trees has been ably discussed by De Candolle, in the *Bibliothèque Universelle* of Geneva, for May, 1831, and in the second volume of his *Physiologie Végétale*; also, more recently, by Professor Alphonse De Candolle. In this country, an article on the subject has appeared in the *North American Review*, for July, 1844.

cessive labors of a great number of generations. The surface or the recent shoots alone are alive; and here life is superficial, all underneath consisting of the dead remains of former generations. The arborescent species are not only lifeless along the central axis, but are dead throughout towards the bottom: as, in a genealogical tree, only the later ramifications are among the living. It is the same with the vegetable, except that, as it ordinarily imbibes its nourishment mainly from the soil through its roots, it makes a downward growth also, and, by constant renewal of fresh tissues, maintains the communication between the two growing extremities, the buds and the rootlets.

233. *Individuality* being imperfectly realized in the vegetable kingdom, the question as to what in the *Phænogamous* plant best answers to the animal individual is speculative, rather than practical, and may be more appropriately noticed in another place. (Part II. Chap. I.)

234. *Comparison of Endogenous with Exogenous Structure.* The woody bundles of an exogenous stem (Fig. 186-188) continue to grow on the outer side as long as the plant lives. In woody trunks they at once become wedges with the point next the pith, and growth proceeds indefinitely by the stratum of perpetually renewed tissue on the outer face between the wood and the bark. Each wedge is separated from its neighbor on both sides by an interposed medullary ray, and is composed of wood on the inner side, liber on the outer, and cambium or forming tissue between. Now each thread or bundle of endogenous wood (204) is composed of similar or analogous parts, sometimes irregularly intermixed, but more commonly similarly disposed. That is, the section of one of these threads exhibits woody tissue and one or two spiral vessels on its inner border, answering to the proper wood, and very thick-walled elongated cells on its outer border, of the same nature as the bast-cells of *Exogens*; and between the two is a stratum of cells of parenchyma mixed with elongated and punctuated cells answering to the proper cells of the inner part of the liber. The portion of each endogenous thread, therefore, which looks towards the centre of the trunk, answers to the wood, and its outer portion to the liber or inner bark, of the exogenous stem; and the parenchyma through which the threads are interspersed answers to the medullary rays and pith together. The main difference between the endogenous woody threads and the exogenous woody wedges is, that there is no cambium-layer in the

former between the liber and the wood, and therefore no provision for increase in diameter. The bundles are therefore strictly limited, while those of Exogens are unlimited in growth. In Exogens the woody bundles or wedges, symmetrically arranged in a circle, become confluent into a zone in all woody and most herbaceous stems, which continues to increase in thickness. In Endogens the woody bundles are unchanged in size after their formation, but new and distinct ones are formed in the growing stem with each leaf it develops, and interspersed more or less irregularly among the older bundles.

CHAPTER V.

OF THE LEAVES.

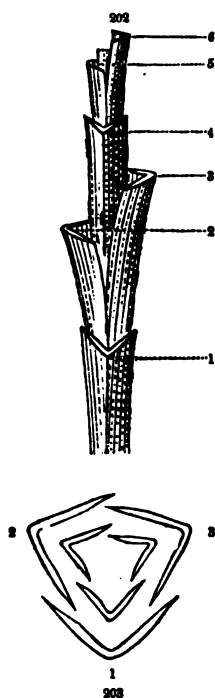
SECT. I. THEIR ARRANGEMENT. (PHYLLOTAXIS, ETC.)

235. THE situation of leaves, as well as their general office in the vegetable economy, and several of their special adaptations, has already been stated. Leaves invariably arise from the nodes (156), just below the point where buds appear. So that wherever a bud or branch is found, a leaf exists, or has existed, either in a perfect or rudimentary state, just beneath it; and buds (and therefore branches), on the other hand, are or may be developed in the axils of all leaves, and do not normally exist in any other situation. The point of attachment of a leaf (or other organ) with the stem is termed its *insertion*. The subject of the arrangement of leaves on the stem has received the name of

236. *Phyllotaxis* (from two Greek words, signifying *leaf-arrangement*).

237. As to their general position, leaves are either *alternate*, *opposite*, or *verticillate*. They are said to be *alternate* (127, and Fig. 121, 157, 204) when there is only one to each node, in which case the successive leaves are thrown alternately to different sides of the stem. They are said to be *opposite* when each node bears a pair of leaves, in which case the two leaves always diverge from each other as widely as possible, that is, they stand on opposite

sides of the stem and point in opposite directions (127, Fig. 107, 210, &c.). They are *verticillate*, or *whorled*, when there are three or more leaves in a circle (*verticil* or *whorl*) upon each node; in which case the several leaves of the circle diverge from each other as much as possible, or are equally distributed around the whole circumference of the axis (Fig. 134, 211). The first of the three is the simplest as well as the commonest method, occurring as it does in almost every Monocotyledonous plant (where it is plainly the normal mode, 128), and in the larger number of Dicotyledonous plants likewise, after the first or second nodes (Fig. 111*, 121). It should therefore be first examined.



238. Alternate Leaves. This general term for the case where leaves are placed one after another, obviously comprises a variety of modes as to the particular position of successive leaves. There is, first, the case to which the name is most applicable, viz. where the leaves are *alternately disposed on exactly opposite sides of the stem* (as in Fig. 157); the second leaf being on the side farthest from the first, while the third is equally distant from the second, and is consequently placed directly over the first, the fourth stands over the second, and so on throughout. Such leaves are accordingly *distichous* or *two-ranked*.* They form two vertical rows: on one side are the 1st, 3d, 5th, 7th, &c.; on the opposite side are the 2d, 4th, 6th, 8th, and so on. This mode occurs in all Grasses, in many other Monocotyledonous plants, and among the Dicotyledonous in the Linden. A second mode is

239. The tristichous or three-ranked arrangement, which is seen in Sedges (Fig.

* In the course of the summer the leaves of *Baptisia perfoliata*, which are really five-ranked, often appear to be *monostichous*, or *one-ranked*; but this is owing to a torsion of the axis.

FIG. 202. Piece of a stalk, with the sheathing bases of the leaves, of a Sedge-Grass (*Carex Crux-corvi*), showing the three-ranked arrangement. 203. Diagram of the cross-section of the same, showing two cycles of leaves.

202) and some other Monocotyledonous plants. Taking any leaf we please to begin with, and numbering it 1, we pass round one third of the circumference of the stem as we ascend to leaf No. 2; another third of the circumference brings us to No. 3; another brings us round to a point exactly over No. 1, and here No. 4 is placed. No. 5 is in like manner over No. 2, and so on. They stand, therefore, in three vertical rows, one of which contains the numbers 1, 4, 7, 10; another, 2, 5, 8, 11; the third, 3, 6, 9, 12, and so on. If we draw a line from the insertion of one leaf to that of the next, and so on to the third, fourth, and the rest in succession, it will be perceived that it winds around the stem spirally as it ascends. In the first or distichous mode, the second leaf is separated from the preceding by half the circumference of the stem; and, having completed one turn round the stem, the third begins a second turn. In the tristichous, each leaf is separated from the preceding and succeeding by one third of the circumference, there are three leaves in one turn, or *cycle*, and the fourth commences a second cycle, which goes on in the same way. That is, the *angular divergence*, or arc interposed between the insertion of two successive leaves, in the first is $\frac{1}{2}$, in the second $\frac{1}{3}$, of the circle. These fractions severally represent, not only the angle of divergence, but the whole plan of these two modes; the numerator denoting the number of times the spiral line winds round the stem before it brings a leaf directly over the one it began with; while the denominator expresses the number of leaves that are laid down in this course, or which form each cycle. The two-ranked mode ($\frac{1}{2}$) is evidently the simplest possible case. The three-ranked ($\frac{1}{3}$) is the next, and the one in which the spiral character of the arrangement begins to be evident. To this succeeds

240. The *pentastichous*, *quincuncial*, or *five-ranked* arrangement (Fig. 204, 205). This is much the most common case in alternate-leaved Dicotyledonous plants. The Apple, Cherry, and Poplar afford ready examples of it. Here there are five leaves in each cycle, since we must pass on to the sixth before we find one placed vertically over the first. To reach this, the ascending spiral line has made two revolutions round the stem, and on it the five leaves are equably distributed, at intervals of $\frac{2}{5}$ of the circumference. The fraction $\frac{2}{5}$ accordingly expresses the angular divergence of the successive leaves; the numerator indicates the number of turns made in completing the cycle, and the denominator gives the number of leaves in the cycle, or the number of vertical ranks of leaves on such

a stem. If we shorten the axis, as it was in the bud, or make a



horizontal plan, we have the parts disposed as in the diagram, Fig. 206, the lower leaves being of course the exterior.

241. The *eight-ranked* arrangement, the next in order, is likewise not uncommon. It is found in the Holly, the Callistemon of our conservatories, the Aconite, the tuft of leaves at the base of the common Plantain, &c. In this case the ninth leaf is placed over the first, the tenth over the second, and so on; and the spiral line makes three turns in laying down the cycle of eight leaves, each separated from the preceding by an arc, or angular divergence, of $\frac{3}{8}$ of the circumference.

242. All these modes, or nearly all of them, were pointed out by Bonnet as long ago as the middle of the last century; but they have recently been extended and generalized, and the mutual relations of the various methods brought to light, by Schimper, Braun, and others. If we write down in order the series of fractions which represent the simpler forms of phyllotaxis already noticed, as determined by observation, viz. $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, we can hardly fail to perceive the relation that they bear to each other. For the numerator of each is composed of the sum of the numerators of the two preceding fractions, and the denominator of the sum of the two preceding denominators. Also the numerator of each fraction is the denominator of the next but one preceding. Extending this series, we obtain the further terms, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, $\frac{21}{55}$, &c. Now these numbers are verified by observation, and, with some abnormal exceptions, this series $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, $\frac{21}{55}$, comprises all the varia-

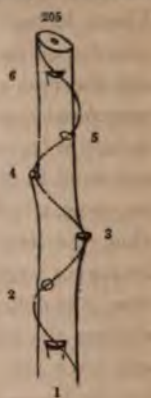


FIG. 204. A branch exhibiting the five-ranked arrangement of leaves.

FIG. 205. Diagram of the same: a spiral line is drawn ascending the stem and passing through the successive scars which mark the position of the leaves from 1 to 6. It is made a dotted line where it passes on the opposite side of the stem, and the scars 2 and 5, which fall on that side, are made fainter. 206. A plane, horizontal projection of the same; the dotted line passing from the edge of the first leaf to the second, and so on to the fifth leaf, which completes the cycle; as the sixth would come directly before, or within, the first.

tions of the arrangement of alternate leaves that actually occur. These higher forms are the most common where the leaves are crowded on the stem, as in the rosettes of the Houseleek (Fig. 207), and the scales of the Pine-cones (for the arrangement extends to all parts that are modifications of leaves), or where they are numerous and small in proportion to the circumference of the stem, as the leaves of Firs, &c. In fact, when the internodes are long and the base of the leaves large in proportion to the size of the stem, it is difficult, and often impossible, to tell whether the 9th, 14th, or 22d leaf stands exactly over the first. And when the internodes are very short, so that the leaves touch one another, or nearly so, we may readily perceive what leaves are superposed; but it is then difficult to follow the succession of the intermediate leaves. The order, however, may be deduced by simple processes.



243. Sometimes we can readily count the number of vertical ranks, which gives the denominator of the fraction sought. Thus, if there are eight, we refer the case to the $\frac{3}{8}$ arrangement in the regular series; if there are thirteen, to the $\frac{5}{13}$ arrangement, and so on. Commonly, however, when the leaves are crowded, the vertical ranks are by no means so manifest as two or more orders of oblique series, or *secondary spirals*, which are at once seen to wind round the axis in opposite directions, as in the Houseleek (Fig. 207; where the numbers, 1, 6, 11 belong to a spire that winds to the left; 1, 9, 17 to another, which winds to the right; and 3, 6, 9, 12 to still another, that winds in the same direction): they are still more obvious in Pine-cones (Fig. 208, 209). These oblique spiral ranks are a necessary consequence of the regular ascending arrangement of parts with equal intervals over the circumference of the axis: and if the leaves are numbered consecutively, these numbers will necessarily stand in arithmetical progression on the oblique ranks, and have certain obvious relations with the primary spiral which originates them; as will be seen by projecting them on a vertical plane.

244. Take, for example, the quincunial ($\frac{2}{5}$) arrangement, where, as in the annexed diagram, the ascending spiral, as written on a plane surface, appears in the numbers 1, 2, 3, 4, 5, 6, and so on:

FIG. 207. An offset of the Houseleek, with the rosette of leaves unexpanded, exhibiting the $\frac{5}{13}$ arrangement; the fourteenth leaf being directly over the first.

the vertical ranks thus formed, beginning with the lowest (which

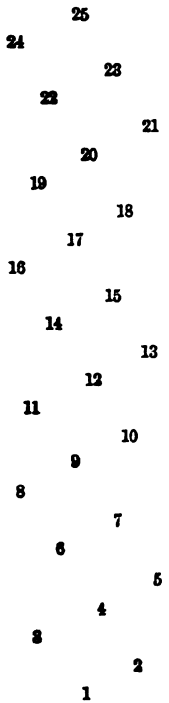


we place in the middle column, that it may correspond with the Larch-cone, Fig. 208, where the lowest scale, 1, is turned directly towards the observer), are necessarily the numbers 1, 6, 11; 4, 9, 14; 2, 7, 12; 5, 10, 15; and 3, 8, 13. But two parallel oblique ranks are equally apparent, ascending to the left; viz. 1, 3, 5, which, if we coil the diagram round a cylinder, will be continued into 7, 9, 11, 13, 15; and also 2, 4, 6, 8, 10, which runs into 12, 14, and so on, if the axis be further prolonged. Here the circumference is occupied by two secondary left-hand series, and we notice that the common difference in the sequence of numbers is two: that is, the number of the parallel secondary spirals is the same as the common difference of the numbers on the leaves that compose them. Again, there are other parallel secondary spiral ranks, three in number, which ascend to the right; viz. 1, 4, 7, continued into 10, 13; 3, 6, 9, 12, continued into 15; and 5, 8, 11, 14, &c.; where again the common difference, 3, accords with the number of such ranks. This fixed relation enables us to lay down the proper numbers on the leaves, when too crowded for directly following their succession, and thus to ascertain the order of the primary spiral series by noticing what numbers come to be superposed in the vertical ranks. We take, for example, the very simple cone of the small-fruited American Larch (Fig. 208), which usually completes only two cycles; for we see that the lowest, one intermediate, and the highest scale, on the side towards the observer, stand in a vertical row. Marking this lowest scale 1, and counting the parallel secondary spirals that wind to the left, we find that two occupy the whole circumference. From 1, we number on the scales of that spiral 3, 5, 7, and so on, adding the common difference 2, at each step. Again, counting from the base the right-hand secondary spirals, we find three of them, and therefore proceed to number the lowest one by adding this common difference, viz. 1, 4, 7, 10; then, passing to the next, on which the No. 3 has already been fixed, we carry on that sequence, 6, 9, &c.; and on the third, where No. 5 is already fixed, we continue the numbering, 8, 11, &c. This gives us, in the vertical rank to which No. 1 belongs, the sequence 1, 6, 11, showing

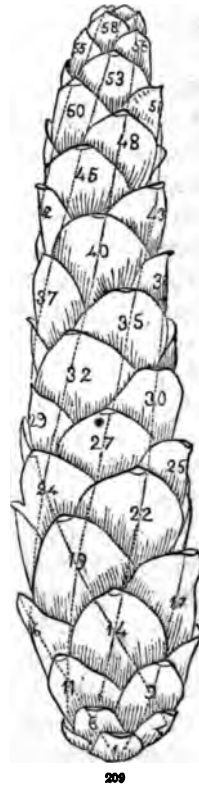
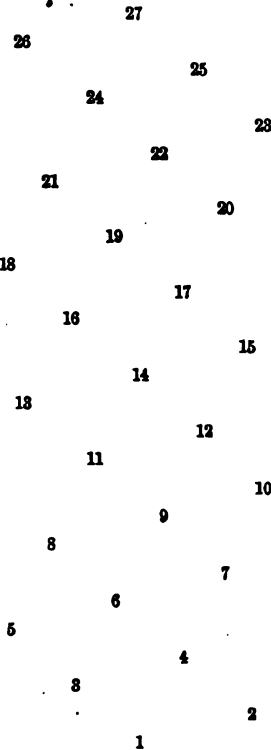
FIG. 208. A cone of the small-fruited American Larch (*Larix Americana*), with the scales numbered, exhibiting the five-ranked arrangement, as in the annexed diagram.

that the arrangement is of the quincuncial ($\frac{2}{3}$) order. It is further noticeable, that the smaller number of parallel secondary spirals, 2, agrees with the numerator of the fraction in this the $\frac{2}{3}$ arrangement; and that this number added to that of the parallel secondary spirals which wind in the opposite direction, viz. 3, gives the denominator of the fraction. This holds good throughout; so that we have only to count the number of parallel secondary spirals in the two directions, and assume the smaller number as the numerator, and the sum

Vertical Projection of the $\frac{2}{3}$ Arrangement.



Vertical Projection of the $\frac{1}{1}$ Arrangement.



of this and the larger number as the denominator, of the fraction which expresses the angular divergence sought. For this we must

FIG 300. A cone of the White Pine, on which the numbers are laid down, and the leading higher secondary spirals are indicated: those with the common difference 8 are marked by dotted lines ascending to the right; two of the five that wind in the opposite direction are also marked with dotted lines: the set with the common difference 3, in one direction, and that with the common difference 2, in the other, are very manifest in the cone.

take, however, the order of secondary spirals nearest the vertical rank in each direction, when there are more than two, as there are in all the succeeding cases.

245. A similar diagram of the $\frac{3}{5}$ arrangement introduces a set of secondary spirals, in addition to the two foregoing, ascending in a nearer approach to a vertical line, and with a higher common difference, viz. 5. There are accordingly five of this sort, viz. those indicated in the diagram by the series 1, 6, 11, 16; 4, 9, 14, 19, 24; 2, 7, 12, 17, 22; 5, 10, 15, 20, 25; and 3, 8, 13, 18, 23. The highest obvious spiral in the opposite direction, viz. that of which the series 1, 4, 7, 10, 13 is a specimen, has the common difference 3, and gives the numerator, and $3 + 5$ the denominator, of the fraction $\frac{3}{8}$. The next case, $\frac{4}{7}$, which is exemplified in the rosettes of the Houseleek (Fig. 207) and in the cone of the White Pine (Fig. 209), introduces a fourth set of secondary spirals, eight in number, with the common difference eight, viz. that of which the series 1, 9, 17, 25 is a representative. The set that answers to this in the opposite direction, viz. 1, 6, 11, 16, 21, 26, with the common difference 5, gives the numerator, and $5 + 8$ the denominator, of the fraction $\frac{5}{13}$. We may here compare the diagram with an actual example (Fig. 209): a part of the numbers are of course out of sight on the other side of the cone. The same laws equally apply to the still higher modes.

246. The order is uniform in the same species, but often various in allied species. Thus, it is only $\frac{3}{5}$ in our common American Larch; in the European species, $\frac{4}{7}$. The White Pine is $\frac{4}{7}$, as is also the Black Spruce; but other Pines with thicker cones exhibit in different species the fractions $\frac{4}{7}$, $\frac{5}{8}$, and $\frac{6}{11}$. Sometimes the primitive spiral ascends from left to right, sometimes from right to left. One direction or the other generally prevails in each species, yet both directions are not unfrequently met with, even in different cones of the same tree.

247. When a branch springs from a stem or parent axis, the spiral is continued from the leaves of the stem to those of the branch, so that the leaf from whose axil the branch arises begins the spire of that branch. When the spire of the branch turns in the same direction as that of the parent axis, as it more commonly does, it is said to be *homodromous* (from two Greek words, signifying *like course*): when it turns in the opposite direction, it is said to be *heterodromous* (or of *different course*).

248. The cases represented by the fractions $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{2}{3}$ are the

most stable and certain, as well as the easiest to observe. In the higher forms, the exact order of superposition often becomes uncertain, owing to a slight torsion of the axis, or to the difficulty of observing whether the 9th, 14th, 22d, 35th, or 56th leaf is truly over the first, or a little to the one side or the other of the vertical line. Indeed, if we express the angle of divergence in degrees and minutes, we perceive that the difference is so small a part of the circumference, that a very slight change will substitute one order for another. The divergence in $\frac{5}{13} = 138^\circ 24'$. In all those beyond, it is 137° plus a variable number of minutes, which approaches nearer and nearer to $30'$. Hence M. Bravais considers all these as mere alterations of one typical arrangement, namely, with the angle of divergence $137^\circ 30' 28''$, which is irrational to the circumference, that is, not capable of dividing it an exact number of times, and consequently never bringing any leaf precisely in a right line over any preceding leaf, but placing the leaves of what we take for vertical ranks alternately on both sides of this line and very near it, approaching it more and more, without ever exactly reaching it. These forms of arrangement he therefore distinguishes as *curviserial*, because the leaves are thus disposed on an infinite curve, and are never brought into exactly straight ranks. The others are correspondingly termed *rectiserial*, because, as the divergence is an integral part of the circumference, the leaves are necessarily brought into rectilinear ranks for the whole length of the stem.

249. A different series of spirals sometimes occurs in alternate leaves, viz. $\frac{1}{4}$, $\frac{1}{5}$, $\frac{2}{8}$, $\frac{3}{12}$; and still others have been detected; but these are rare or exceptional cases.

250. *Opposite Leaves* (237, Fig. 210). In these, almost without exception, the second pair is placed over the intervals of the first, the third over the intervals of the second, and so on. More commonly, as in plants of the Labiate or Mint Family, the successive pairs cross each other exactly at right angles, so that the third pair stands directly over the first, the fourth over the second, &c., forming four equidistant vertical ranks for the



FIG. 210. Opposite leaves of the Strawberry-bush, or *Euonymus Americanus*.

whole length of the stem. In this case, the leaves are said to be *decussate*. In other cases, as in the Pink Family, often the succes-



sive pairs deviate a little from this line, so that we have to pass several pairs before we reach one exactly superposed over the pair we start with. This indicates a spiral arrangement, which falls into some one of the modes already illustrated in alternate leaves; only that here each node bears a pair of leaves.

251. Verticillate or Whorled Leaves (Fig. 211)

follow the same modes of arrangement as opposite leaves. Sometimes they *decussate*, or the leaves of one whorl correspond to the intervals of that underneath, making twice as many vertical ranks as there are leaves in the whorl; sometimes they wind spirally, so that each leaf of the whorl belongs to as many parallel spirals, analogous to the secondary spirals in the case of alternate leaves.

252. The opposition or alternation of the leaves is generally constant in the same species, and often through the same family; yet both modes occasionally occur on the same stem, as in the common Snapdragon and the Myrtle. All Exogens, having their cotyledons opposite, necessarily commence with that mode (Fig. 103-125); many retain it throughout; others change to alternation, either directly in the primordial leaves (Fig. 111*, 121), or at a later period. In Endogens, on the contrary, the first leaves are necessarily alternate (128), and it is seldom that they afterwards exhibit opposite or whorled leaves. The Pine in germination commences with a whorl of leaves (Fig. 133, 134); but the subsequent ones are alternate. The Pine, however (Fig. 212), and the Larch, bear what are termed



FIG. 211. Verticillate or whorled leaves of a Gallum or Bedstraw.

FIG. 212. Piece of a branchlet of Pitch Pine, with three leaves in a fascicle or bundle, in the axil of a thin scale (a) which answers to a primary leaf. The bundle is surrounded at the base by a short sheath, formed of the delicate scales of the axillary bud.

253. *Fascicled Leaves*. These are really the leaves of an axillary bud. They remain in a tuft or cluster because the axis of

the bud does not lengthen. This is plainly seen in the spring leaves of the Barberry and of the Larch (Fig. 213), crowded on short spurs, some of which soon elongate into ordinary shoots with scattered alternate leaves. Their nature is less evident in Pines, on account of the peculiar character of the leaves of the main axis, from whose axil the tuft of two, three, or five leaves arises, the primary leaf in this case being a thin and chaffy scale (Fig. 212, *a*) which soon falls off, while the actual foliage all belongs to the axillary clusters. So in the common Barberry the proper leaves of the lengthened stems are chiefly in the form of spines (Fig. 296), and the actual foliage appears in fascicles in their axils.



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254. As regards their general position on the stem, leaves are said to be *radical*, when they are borne on the stem at or below the surface of the ground, so as apparently to grow from the root, as those of the Bloodroot, Plantain, Primrose, and of the acaulescent (154) Violets: those that arise along the main stem are termed *cauline*; those of the branches, *rameal*; and those which stand upon or at the base of flower-branches are called *floral*; the latter, moreover, are generally termed *bracts*.

255. With respect to succession, those leaves which manifestly exist in the embryo are called *seminal*; the first or original pair receiving the name of *cotyledons* (120), and usually differing widely in appearance from the *ordinary* leaves which succeed them. The earliest ordinary leaves are termed *primordial*. These, as well as the cotyledons, usually perish soon after others are developed to supply their place.

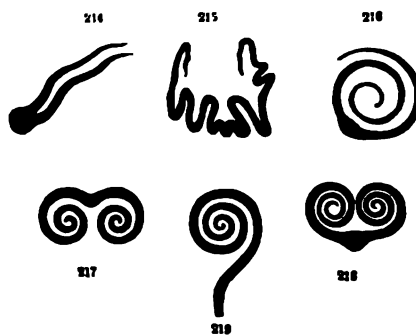
256. As pertaining to the arrangement of leaves, we should here notice the modes in which they are disposed before expansion in the bud; namely, their

257. *Vernation or Præfoliation*. The latter is the most characteristic name, but the former, given by Linnaeus (literally denoting their spring state), is the more ancient and usual. Two things are included under this head:—1st, the mode in which each leaf considered separately is disposed; 2d, the arrangement of the several

FIG. 213. Piece of a branchlet of the Larch, with two fascicles of leaves.

leaves of the same but in respect to each other. This last is evidently connected with the phyllotaxis, or their position and order of succession on the stem. As to the first, leaves are for the most part either *bent*, or *folded*, or *rolled up* in veneration. Thus, the upper part may be bent on the lower, so that the apex of the leaf is brought down towards the base, as in the Tulip-tree, when the leaves are *inflexed* or *reclinate* in veneration: or the leaf may be folded along the midrib or axis, so that the right half and the left half are applied together, as in the Oak and the Magnolia, when the leaves are *conduplicate*: or each leaf may be folded up a certain number of times like a fan, as in the Maple, Currant, and Vine, when they are said to be *plicate* or *plaited*. The leaf may be rolled either parallel with its axis, or on its axis. In the latter case it is spirally rolled up from the apex towards the base, like a crosier, or *circinnate*, as in true Ferns (Fig. 100), and among Phænogamous plants in the Drosera or Sundew. Of the former there are three ways; viz. the whole leaf may be laterally rolled up from one edge into a coil, with the other edge exterior, when the leaves are said to be *convolute*, as in the Apricot and Cherry; or both edges may be equally rolled towards the midrib; either inwards, when they are *involute*, as in the Violet and the Water-Lily; or else outwards, when they are *revolute*, as in the Rosemary and Azalea. Fig. 214-219 are Linnæan diagrams of sections of leaves, illustrating the principal modes of veneration.

256. Considered relatively to each other, leaves are *valvate* in veneration when corresponding ones touch each other by their edges



only, without overlapping: they are *imbricated* when the outer successively overlap the inner, by their edges at least, in which case the order of overlapping exhibits the phyllotaxis, or order of succession and position. In these cases

the leaves are plane or convex, or at least not much bent or rolled.

FIG. 214. Conduplicate; 215. Plicate or plaited; 216. Convolute; 217. Revolute; 218. Involute; and, 219. Circinnate, veneration.

When leaves with their margins involute are applied together in a circle without overlapping, the vernation is *induplicate*. When, in conduplicate leaves, the outer successively embrace or sit astride of those next within, the vernation is *equitant*, as the leaves of the Iris at their base (Fig. 296); or when each receives in its fold the half of a corresponding leaf folded in the same manner, the vernation is *half-equitant* or *obvolute*. These terms equally apply to leaves in their full-grown condition, whenever they are then so situated as to overlies or embrace one another. They likewise apply to the parts in the flower-bud, under the name of *æstivation* or *præfloration*. Chap. IX. Sect. V.

SECT. II. THEIR STRUCTURE AND CONFORMATION.

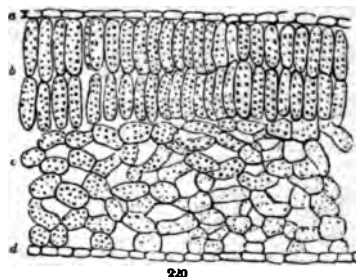
259. *Anatomy of the Leaf.* The complete leaf consists of the **BLADE** (*Lamina* or *Limb*, Fig. 229, *b*), with its **PETIOLE** or *Leaf-stalk*, *p*, and at its base a pair of **STIPULES**, *st*. Of these the latter are frequently absent altogether, and in many cases where they originally exist they fall away as the leaf expands. The petiole is very often wanting; when the leaf is *sessile*, or has its blade resting immediately on the stem that bears it (as in Fig. 210, 211). Sometimes, moreover, there is no proper blade, but the whole organ is cylindrical or stalk-like. It is the general characteristic of the leaf, however, that it is an expanded body. Indeed, it may be viewed as a contrivance for increasing the green surface of a plant, so as to expose to the light and air the greatest practicable amount of parenchyma containing the green matter of vegetation (*chlorophyll*, 92), upon which the light exerts its peculiar action. Leaves as foliage, accordingly, are what we are now principally to consider

260. In a general, mechanical way, it may be said leaves are definite protrusions of the green layer of the bark, expanded horizontally into a thin lamina, and stiffened by tough, woody fibres (connected both with the liber, or inner bark, and the wood), which form its framework, *ribs*, or *veins*. Like the stem, therefore, the leaf is made up of two distinct parts, the *cellular* and the *woody*. The cellular portion is the green pulp or parenchyma: the woody, is the skeleton or framework which ramifies among and strengthens the former. The woody or fibrous portion fulfils the same purposes in the leaf as in the stem, not only giving firmness and support to the

delicate cellular apparatus, but also serving for the conveyance and distribution of the sap. The subdivision of these *ribs*, or *veins*, of the leaf, as they are not inappropriately called, continues beyond the limits of unassisted vision, until the bundles or threads of woody tissue are reduced to very delicate fibres, ramified throughout the green pulp.

261. The cellular portion of the leaf consists of thin-walled cells of loose parenchyma, containing grains of *chlorophyll*, to which the green color of foliage is entirely owing. The cells are not heaped promiscuously, but exhibit a regular arrangement; upon a plan, too, which varies in different parts of the leaf, according to the different conditions in which it is placed.

262. Leaves are almost always expanded horizontally, so as to present one surface to the ground and the other to the sky; and the parenchyma forms two general strata, one belonging to the upper and the other to the lower side. The microscope displays a manifest difference in the parenchyma of these two strata. That of the upper stratum is composed of one or more compact layers of oblong cells, placed endwise, or with their long diameter perpendicular to the surface; while that of the lower stratum is very loosely arranged, leaving numerous vacant spaces between the cells; and when the cells are oblong, their longer diameter is parallel with the epidermis. This is shown in Fig. 7, which represents a magnified section through the thickness (perpendicular to the surface) of a leaf of the Star-Anise of Florida; where the upper stratum of



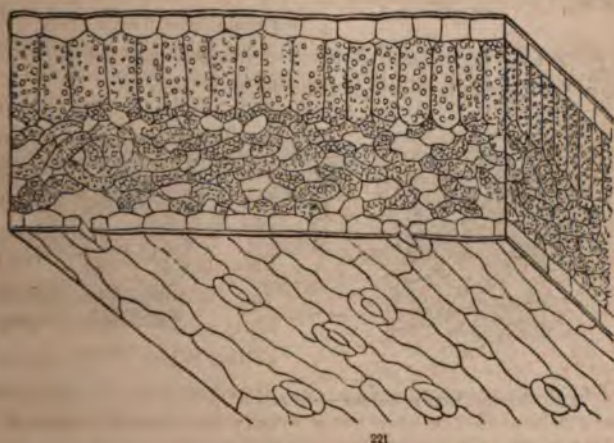
parenchyma consists of only a single series of perpendicular cells. Also in Fig. 220, which represents a similar view of a thin slice of a leaf of the Garden Balsam. Fig. 221 represents a piece cut out of a leaf of the White Lily; where the upper stratum is composed of only one compact layer of ver-

tical cells. The parenchyma is alone represented; the woody portion, or veins, being left out. The more compact structure of the

FIG 220. Magnified section through the thickness of a leaf of the Garden Balsam: *a*, section of the epidermis of the upper surface; *b*, of the upper stratum of parenchyma; *c*, of the lower stratum; *d*, of the epidermis of the lower surface. (After Brongniart.)

upper stratum shows why the upper surface of leaves is of a deeper green than the lower.

263. The object which this arrangement subserves will appear evident, when we consider that the spaces between the cells, filled with air, communicate freely with each other throughout the leaf, and also with the external air by means of openings in the epidermis (presently to be described); and when we consider the powerful action of the sun to promote evaporation, especially in dry air; and that the thin walls of the cells, like all vegetable membrane, allow of the free escape of the contained moisture by transudation. The compactness of the cells of that stratum which is presented immediately to the sun, and their vertical elongation, so that each shall expose the least possible surface, obviously serve to protect the loose parenchyma beneath from the too powerful action of direct sunshine. This provision is the more complete in the case of plants which retain their foliage through a season of drought in arid regions, where the soil is usually so parched during the dry season, that, for a long period, it affords only a scanty supply of moisture to the roots. Compare, in this respect, a leaf of the Lily (Fig. 221), where the upper stratum contains but a single layer of barely oblong cells, with the firm and more enduring leaf of the Oleander, the



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upper stratum of which consists of two layers of long and narrow vertical cells as closely compacted as possible (Fig. 222). So dif-

FIG. 221. A magnified section through the thickness of a minute piece of the leaf of the White Lily of the gardens, showing also a portion of the under side with some breathing-pores.

ferent is the organization of the two strata, that a leaf soon perishes if reversed so as to expose the lower surface to direct sunshine.

264. A further and more effectual provision for restraining the perspiration of leaves within due limits is found in the *Epidermis*, or skin, that invests the leaf, as it does the whole surface of the vegetable (69), and which is so readily detached from the succulent leaves of such plants as the Stonecrop and the Live-for-ever (*Sedum*) of the gardens. The epidermis is composed of small cells belonging to the outermost layer of cellular tissue, with the pretty thick-sided walls very strongly coherent, so as to form a firm membrane. Its cells contain no chlorophyll. In ordinary herbs that allow of ready evaporation, this membrane is made up of a single layer of cells; as in the Lily, Fig. 221, and the Balsam, Fig. 220. It is composed of two layers in cases where one might prove insufficient; and in the Oleander, besides the provision against too copious evaporation, already described (263), the epidermis consists of three compact layers of very thick-sided cells (Fig. 222). It is generally thick, or hard and impermeable, in the firm leaves of the *Pittosporum*, *Laurustinus*, and other plants, which will thrive, for this



very reason, where those of more delicate foliage are liable to perish, in the dry atmosphere of our rooms in winter.



FIG. 222. Magnified section through a part only of the thickness of a leaf of the Oleander, showing the epidermis of the upper surface, formed of three layers of thick-walled cells and the two very compact layers of cylindrical cells standing endwise.

FIG. 223. Magnified slice of the epidermis and superficial parenchyma of a Cactus, after Schleiden; exhibiting the epidermis (a) greatly thickened by a stratified deposition in the cells: and some cells of the parenchyma likewise nearly filled with an incrusting deposit. The deposition in such cases is always irregular, leaving canals or passages which nearly connect the adjacent cells. Several of the cells contain crystals (94).

FIG. 224. Similar section from another species of Cactus, passing through one of the stomata, and the deep intercellular space beneath it.

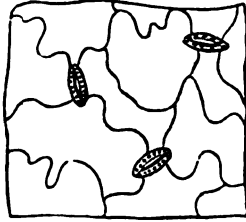
265. In such firm leaves, especially, the walls of the epidermal cells are soon thickened by internal deposition (44), especially on the superficial side. This is well seen in the epidermis of the Aloe, and in other fleshy plants, which bear severe drought with impunity: in Fig. 223, it is shown, at *a*, in the rind of a Cactus, in which the green layer of the whole stem answers the purpose of leaves. Sometimes an exterior layer of this superficial deposit in the epidermis may be detached in the form of a continuous, apparently structureless membrane, which Brongniart and succeeding authors have called the CUTICLE. That it may shed water readily, the surface of leaves is commonly protected by a very thin varnish of wax, or else with a *bloom* of the same substance in the form of a whitish powder, which easily rubs off (85), as is familiarly seen in a Cabbage-leaf.

266. A thickening deposit sometimes takes place in the cells of parenchyma immediately underneath the epidermis, especially in the Cactus Family, where the once thin and delicate walls of the cells become excessively and irregularly thickened (Fig. 223, 224), so as doubtless to arrest or greatly obstruct exhalation through the rind. Something like this choking of the cells must commonly occur with age in most leaves, particularly those that live for more than one season (311).

267. But the multiplication of these safeguards against exhalation might be liable to defeat the very objects for which leaves are principally destined. Evaporation from the parenchyma of the leaves is essential to the plant, as it is the only method by which its excessively dilute food can be concentrated. Some arrangement is requisite that shall allow of sufficient exhalation from the leaves while the plant is freely supplied with moisture by the roots, but restrain it when the supply is deficient. It is clear that the greatest demand is made upon the leaves at the very period when the supply through the roots is most likely to fail; for the summer's sun, which acts so powerfully on the leaves, at the same time parches the soil upon which the leaves (through the rootlets) depend for the moisture they exhale. So long as their demands are promptly answered, all goes well. The greater the force of the sun's rays, the greater the speed at which the vegetable machinery is driven. But whenever the supply at the root fails, the foliage begins to flag and droop, as is so often seen under a sultry meridian sun; and if the exhaustion proceeds beyond a certain point, the leaves inevitably wither and perish.

Some adaptation is therefore needed, analogous to a self-acting valve, which shall regulate the exhalation according to the supply. Such an office is actually fulfilled by

268. The *Stomata*, *Stomates*, or *Breathing-pores* (70). Through the orifices which bear this name, exhalation principally takes place, in all ordinary cases, where the epidermis is thick and firm enough to prevent much escape of moisture by direct transudation. The



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stomata (Fig. 225 – 228) are always so situated as to open directly into the hollow chambers, or air-cavities, which pervade the parenchyma (Fig. 221), especially the lower stratum, so as to afford free communication between the external air and the whole interior of the leaf. The perforation of the epidermis is between two (or rarely four)

delicate and commonly crescent-shaped cells, which, unlike the rest of the epidermis, usually contain some chlorophyll, and in other respects resemble the parenchyma beneath. When moistened these guardian-cells change their form, becoming more crescentic as they become more turgid, thereby separating in the middle and opening a free communication between the outer air and the interior of the leaf. As they become drier, they shorten and straighten, so as to bring the sides of the two into contact and close the orifice.* The use of this mechanism will be readily understood. So long as the leaf

* They expand and contract most in the direction of their length; and the elongation and increased curvature when moist draws in the concave side and so enlarges the aperture. The mechanism of the opening and shutting of stomata has been recently investigated by Mohl (in *Bot. Zeitung* for 1856, p. 697, — an abstract of the memoir is given by C. F. Stone in *Amer. Journal of Science* for March, 1857), — and these facts verified. The peculiar change of the guardian-cells in form seems not entirely susceptible of mechanical explanation, and is partly controlled (like other vegetable movements) by the light of the sun; but it mainly depends upon endosmose. Mohl has clearly shown that, while the guardian-cells themselves act so as to open the stomate in moisture and close it in dryness, the adjacent cells of the epidermis in swelling when moist tend to close the stomate, and their contraction when dry to open it; — so that the actual position at any time is a resultant of nicely adjusted opposing forces.

FIG. 225. A highly magnified piece of the epidermis of the Garden Balsam, with three stomata (after Brongniart).

is in a moist atmosphere, and is freely supplied with sap, the stomates remain open, and allow the free escape of moisture by evaporation. But when the supply fails, and the parenchyma begins to be exhausted, the guardian-cells, at least equally affected by the dryness, promptly collapse, and by closing these thousands of apertures check the drain the moment it becomes injurious to the plant.

269. As a general rule, the stomata wholly or principally belong to the epidermis of the lower surface of the leaf: the mechanism is too delicate to work well in direct sunshine. The position of the stomata, and the loose texture of the lower parenchyma, require that this surface should be shielded from the sun's too direct and intense action ;



and show why leaves soon perish when artificially reversed, and prevented from resuming (as otherwise they spontaneously will) their natural position. This general arrangement is variously modified, however, under peculiar circumstances. The stomata are equally distributed on the two sides of those leaves, of whatever sort, which grow in an erect position, or present their edges, instead of their surfaces, to the earth and sky (294), and have the parenchyma of both sides similarly constituted, sustaining consequently the same relations to light. In the Water-Lilies (*Nymphæa*, *Nuphar*), and other leaves which float upon the water, the stomata all belong to the upper surface. All leaves which live under water, where there can be no evaporation, are destitute, not only of stomata, but usually of a distinct epidermis also.

270. The number of the stomata varies in different leaves from 800 to about 170,000 on the square inch of surface. In the Apple, there are said to be about 24,000 to the square inch (which is under the average number, as given in a table of 36 species by Lindley) ; so that each leaf of that tree would present about 100,000 of these orifices. When the stomata are not all restricted to the lower surface, still the greater portion usually occupy this position. Thus, the leaf of *Arum Dracontium* is said to have 8,000 stomata to a square inch of the upper surface, and twice that number in the

FIG. 226. Magnified view of the 10,000th part of a square inch of the epidermis of the lower surface of the leaf of the White Lily, with its stomates. 227. A single stomate, more magnified. 228. Another stomate, widely open.

same space of the lower. The leaf of the Coltsfoot has 12,000 stomata to a square inch of the lower epidermis, and only 1,200 in the upper. That of the White Lily has from 20,000 to 60,000 to the square inch on the lower surface, and perhaps 3,000 on the upper. In this plant, and in other true Lilies, they are so remarkably large (Fig. 221, 226 - 228) that they may be discerned by a simple lens of an inch focus. In most plants they are very much smaller than this.

271. Succulent or fleshy plants, such as those of the Cactus tribe, *Mesembryanthemums*, *Sedums*, *Aloes*, &c., are remarkable for holding the water they imbibe with great tenacity, rather in consequence of the thickness of the epidermis, or from the deposit which early accumulates in the superficial cells of the parenchyma (266), than from the want of stomata. The latter are usually abundant,* but they seem to open less than in ordinary plants, except in young and growing parts. Hence the tissue becomes gorged as it were with fluid, which is retained with great tenacity, especially during the hot season. They are evidently constructed for enduring severe droughts; and are accordingly found to inhabit dry and sunburnt places, such as the arid plains of Africa, — the principal home of the *Stapelias*, *Aloes*, succulent *Euphorbias*, &c., — or the hottest and driest parts of our own continent, to which the whole Cactus family is indigenous. Or, when such plants inhabit the cooler temperate regions, like the *Sedums* and the common *Houseleek*, &c., they are commonly found in the most arid situations, on naked rocks, old walls, or sandy plains, exposed to the fiercest rays of the noonday sun, and thriving where ordinary plants would speedily perish. The drier the atmosphere, the greater their apparent reluctance to part with the fluid they have accumulated, and upon which they live during the long period when little or no moisture is yielded by the soil or the air. Their structure and economy fully explain their tolerance of the very dry air of our houses in midwinter, when ordinary thin-leaved plants become unhealthy or perish.

272. Sometimes the leaves of succulent plants merely become obese or misshapen, like those of the *Ice-plant* and other species

* The thickened epidermis of the fleshy leaves of the *Sea-Sandwort* (*Honkenya*) is provided with an abundance of large stomata, on the upper as well as the lower face. But this plant, though very fleshy, grows in situations where its roots are always supplied with moisture.

of *Mesembryanthemum*, &c.: sometimes they are reduced to triangular projections or points, or are perfectly confounded with the green bark of the stem, which fulfils their office, as in the *Stapelia* and most *Cacti*.

273. *The Development of Leaves.* At their first appearance, each leaf is a minute papilla or projection of parenchyma on the nascent axis: as it grows, this shapes itself into the blade, and is eliminated from the axis. The petiole, if any, is later formed, and by its growth raises the blade from the stem. Commonly the apex of the blade first appears, and the formation proceeds from above downwards. The sheath at the base (as in most *Monocotyledons*), or the stipules (259, which principally belong to *Dicotyledons*), are at first continuous with the blade, or divided from it by a mere constriction: the formation and elongation of the petiole soon separate them. The stipules, remaining next the axis or source of nourishment, undergo a rapid development early in the bud, so that, at a certain stage, they are often larger than the body of the leaf, and they accordingly form in such cases the teguments of the bud. Divided or lobed and compound leaves are simple at the commencement, but the lobes are very early developed; they grow in respect to the axis of the leaf nearly as that grew from the axis of the plant, and in the compound leaf at length isolate themselves, and are often raised on footstalks of their own. Commonly the upper lobes or leaflets are first formed, and then the lower: but in those of the *Walnut* and *Ailanthus*, and other large compound leaves, the formation proceeds from below upwards, and new leaflets continue to be produced from the apex, even after the lowermost are nearly full grown. In the earliest stage leaves consist of parenchyma alone: the fibro-vascular tissue which makes the ribs, veins, or framework appears later.

274. At the points on the surface of the developing leaf where stomata are about to be formed, one of the epidermal cells early ceases to enlarge and thicken with the rest, but divides into two (in the manner formerly described, 33), forming the two guardian-cells of the stomate: as they grow, the two constituent portions of their common partition separate, leaving an interspace or orifice between. In some cases, each new cell divides again, when the stomate is formed of four cells in place of two.

275. *The Forms of Leaves* are almost infinitely various. These afford some of the readiest, if not the most certain, marks for

characterizing species. Their principal modifications are therefore classified, minutely defined, and embodied in a system of nomenclature which is equally applicable to other parts of the plant, and which as an instrument is indispensable to the systematic botanist. The numerous technical terms which have gradually accumulated from the infancy of the science, and have multiplied with its increasing wants, are mostly quite arbitrary, or have been suggested by real or fancied resemblances of their shapes to various natural or other objects. This arbitrary nomenclature, which formerly severely tasked the memory of the student, was reduced by De Candolle to a clear and consistent system, based upon scientific principles, and of easy application. The fundamental idea of the plan is, that the almost infinite varieties in the form and outline of leaves may be deduced from the different modes and degrees in which the woody skeleton or framework of the leaf is expanded or ramified in the parenchyma. Upon this conception the following sketch is based; in which all the more important terms of the nomenclature of leaves are mentioned and defined. It should be kept in mind, however, that this is not to be taken as an explanation of the actual formation of leaves; but rather as an account of the mutual adaptation and correspondence of their outlines and framework. For the parenchyma is developed, and the form of the leaf more or less determined, before the framework has an existence. The latter, therefore, cannot have given rise to the outline or shape of the organ. The distribution of the veins or fibrous framework of the leaf in the blade is termed its

276. *Venation.* The veins are distributed throughout the lamina in two principal modes. Either the vessels of the petiole divide at once, where they enter the blade, into several veins, which run parallel with each other to the apex, connected only by simple transverse veinlets (as in Fig. 230); or the petiole is continued into the blade in the form of one or more principal or coarser veins, which send off branches on both sides, the smaller branchlets uniting with one another (*anastomosing*) and forming a kind of network; as in Fig. 229. The former are termed *parallel-veined*, or commonly *nerved* leaves; the veins in this case having been called nerves by the older botanists,—a name which it is found convenient to retain, although of course they are in no respect analogous to the nerves of animals. The latter are termed *reticulated* or *netted-veined* leaves.

277. Parallel-veined or nerved leaves are characteristic of Endogenous plants; while reticulated leaves are almost universal in



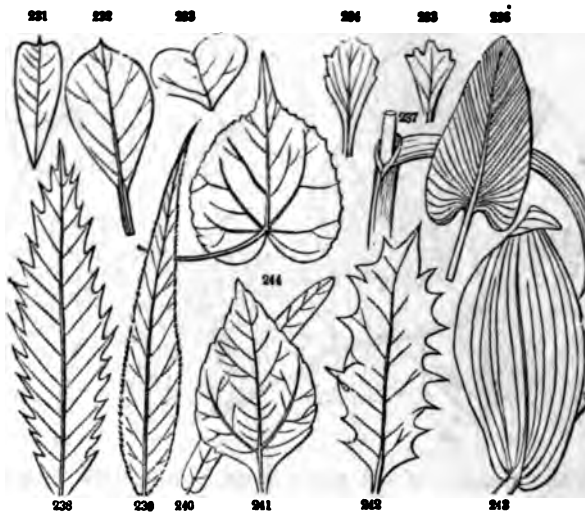
Exogenous plants. We are thus furnished with a very obvious, although by no means absolute, distinction between these two great classes of plants, independently of the structure of their stems (198).

278. In reticulated leaves, the coarse primary veins (one or more in number), which proceed immediately from the apex of the petiole, are called *ribs*; the branches are termed *veins*, and their subordinate ramifications, *veinlets*. Very frequently, a single strong rib (called the *midrib*), forming a continuation of the petiole, runs directly through the middle of the blade to the apex (Fig. 229, 238, &c.), and from it the lateral veins all diverge. Such leaves are termed *feather-veined* or *pinnately veined*; and are subject to various modifications, according to the arrangement of the veins and veinlets; the primary veins sometimes passing straight from the midrib to the margin, as in the Beech and Chestnut (Fig. 238); while in other cases they are divided into veinlets long before they reach the margin. When the midrib gives off a very strong primary vein or branch on each side above the base, the leaf is said to be *triple-ribbed*, or often *triply-nerved*, as in the common Sunflower (Fig.

FIG. 229. A leaf of the Quince, of the netted-veined or reticulated sort: *b*, blade; *p*, petiole or leaf-stalk; *st*, stipules.

FIG. 230. Parallel-veined leaf of the Lily of the Valley.

241); if two such ribs proceed from each side of the midrib, it is said to be *quintuple-ribbed*, or *quintupli-nerved*.



279. Not unfrequently the vessels of a reticulated leaf divide at the apex of the petiole into three or more portions or ribs of nearly equal size, which are usually divergent, each giving off veins and veinlets, like the single rib of a feather-veined leaf. Such leaves are termed *radiated-veined*, or *palmately-veined*; and, as to the number of the ribs, are called three-ribbed, five-ribbed, seven-ribbed, &c. (Fig. 244, 247, 253). Examples of this form are furnished by the Maple, the Gooseberry, the Mallow family, &c. Occasionally the ribs of a radiated-veined leaf converge and run to the apex of the blade, as in *Rhexia* and other plants of the same family, thus resembling a parallel-veined or nerved leaf; from which, however, it is distinguished by the intermediate netted veins. But when the ribs are not very strong, such leaves are frequently said to be nerved, although they branch before reaching the apex.

280. According to the theory of De Candolle (275), the shape which leaves assume may be viewed as dependent upon the distribution of the veins, and the quantity of parenchyma; the general outline being determined by the division and direction of the veins; and the form of the margin, (whether even and continuous, or else interrupted by void spaces or indentations,) by the greater or

FIG. 231 - 244. Various forms of simple leaves.

less abundance of the parenchyma in which the veins are distributed. This view is readily intelligible upon the supposition that a



leaf is an expansion of soft parenchyma, in which the firmer veins are variously ramified. Thus, if the principal veins of a feather-veined leaf are not greatly prolonged, and are somewhat equal in length, the blade will have a more or less elongated form. If the veins are very short in proportion to the midrib, and equal in length, the leaf will be *linear* (as in Fig. 240); if longer in proportion, but still equal, the leaf will assume an *oblong* form (Fig. 242), which a slight rounding of the sides converts into an *oval* or *elliptical* outline. If the veins next the base are longest, and especially if they curve forward towards their extremities, the leaf assumes a *lanceolate* (Fig. 239), *ovate* (Fig. 241), or some intermediate form. On the other hand, if the veins are more developed beyond the middle of the blade, the leaf becomes *obovate* (Fig. 232), or *cuneiform* (Fig. 235). In radiated or palmately veined leaves (Fig. 245-253), where the primary ribs are divergent, an orbicular or roundish outline is most common. When some of the ribs or their ramifications are directed backwards, a recess, or *sinus*, as it is termed, is produced at the base of the leaf, which, taken in connection with the general form, gives rise to such terms as *cordate* or *heart-shaped* (Fig. 244), *reniform* or *kidney-shaped* (Fig. 245), &c., when the posterior portions are rounded; and those of *sagittate* or *arrow-headed* (Fig. 252), and *hastate* or *halberd-shaped* (Fig. 250), when

FIG. 245-253. Forms of simple, chiefly radiated-veined leaves.

the angles or lobes at the base diverge. The margins of the sinns are sometimes brought into contact and united, when the leaf becomes *peltate* or *shield-shaped* (Fig. 248); the blade being attached to the petiole, not by its apparent base, but by some part of the lower surface. Two or three common species of *Hydrocotyle* plainly exhibit the transition from common radiated leaves into the peltate form. Thus, the leaf of *H. Americana* (Fig. 247) is roundish-reniform, with an open sinus at the base, while in *H. interrupta* and *H. umbellata* (Fig. 248), the margins have grown together so as to obliterate the sinus, and an orbicular peltate leaf is produced. In nerved leaves, when the nerves run parallel from the base to the apex, as in Grasses (Fig. 237), the leaf is necessarily linear, or nearly so; but when they are more divergent in the middle, or towards the base, the leaf becomes oblong, oval, or ovate, &c. (Fig. 243). In one class of nerved or parallel-veined leaves, the simple veins or nerves arise from a prolongation of the petiole in the form of a thickened midrib, instead of the base of the blade, constituting the *currinerved* leaves of De Candolle. This structure is almost universal in the Ginger tribe, the Arrowroot tribe, in the Banana, and other tropical plants; and our common *Pontederia*, or Pickerel-weed (Fig. 236), affords an illustration of it, in which the nerves are curved backwards at the base, so as to produce a cordate outline.

281. As to the margin and particular outline of leaves, they exhibit every gradation between the case where the blade is *entire*, that is, with the margin perfectly continuous and even (as in Fig. 243), and those where it is cleft or divided into separate portions. The convenient hypothesis of De Candolle connects these forms with the abundance or scantiness of the parenchyma, compared with the divergence and the extent of the ribs or veins; on the supposition that, where the former is insufficient completely to fill up the framework, *lobes*, *incisions*, or *toothings* are necessarily produced, extending from the margin towards the centre. Thus, in the white and the yellow species of *Water Ranunculus*, there appears to be barely sufficient parenchyma to form a thin covering for each vein and its branches (Fig. 251, the lowest leaf); such leaves are said to be *filiformly dissected*, that is, *cut into threads*; the nomenclature in all these cases being founded on the convenient (but incorrect) supposition, that a leaf originally entire is *cut into teeth, lobes, divisions, &c.* If, while the framework remains the same as in the last instance, the parenchyma be more abun-

dantly developed, as in fact happens in the upper leaves of the same species when they grow out of water, and is shown in the same figure, they are merely *cleft* or *lobed*. If these *lobes* grow together nearly to the extremity of the principal veins, the leaf is only *toothed*, *serrated*, or *crenated*; and if the small remaining notches were filled with parenchyma, the leaf would be *entire*. The study



of the development of leaves, however, proves that the parenchyma grows and shapes the outlines of the organ in its own way, irrespective of the framework, which is, in fact, adapted to the parenchyma rather than the parenchyma to it. The principal terms which designate the mode and degree of division in simple leaves may now be briefly explained, without further reference to this or any other theory.

282. A leaf is said to be *serrate*, when the margin is beset with sharp teeth which point forwards towards the apex (Fig. 254); *dentate*, or *toothed*, when the sharp salient teeth are not directed towards the apex of the leaf (Fig. 255); and *crenate*, when the teeth are rounded (Fig. 248, 256). A slightly waved or sinuous margin is said to be *repand* (Fig. 257); a more strongly uneven margin, with alternate rounded concavities and convexities, is termed *sinuate* (Fig. 258). When the leaf is irregularly and sharply cut deep into the blade, it is said to be *incised* (Fig. 259); when the portions (or *segments*) are more definite, it is said to be *lobed* (Fig. 260, 264); and the terms *two-lobed*, *three-lobed* (Fig. 264), *five-lobed*, &c., express the number of the segments. If the incisions extend about to the middle of the blade, or somewhat deeper, and especially if the sinuses are acute, the leaf is said to be *cleft* (Fig. 261, 265); and the terms *two-cleft*, *three-cleft* (Fig. 265), &c. (or in the Latin form, *bifid*, *trifid*, &c.), designate the number of the segments; or when the latter are numerous or indefinite, the leaf is termed *many-cleft*, or *multifid*. If the segments extend nearly, but not quite, to the

FIG. 254-259. Forms of leaves as to the tothing of their margins.

base of the blade or the midrib, the leaf is said to be *parted* (Fig. 262, 266): if they reach the midrib or the base, so as to interrupt



the parenchyma, the leaf is said to be *divided* (Fig. 263, 267); the number of *partitions* or *divisions* being designated, as before, by the terms *two-, three-, five-parted*, or *two-, three-, five-divided*, &c.

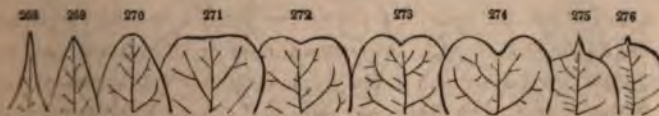
283. As the mode of division always coincides with the arrangement of the primary veins, the lobes or incisions of feather-veined, are differently arranged from those of radiated or palmately veined leaves: in the latter, the principal incisions are all directed to the base of the leaf; in the former, towards the midrib. These modifications are accurately described by terms indicative of the venation, combined with those that express the degree of division. Thus, a feather-veined (in the Latin form, a *pinnately veined*) leaf is said to be *pinnately cleft* or *pinnatifid* (Fig. 261), when the sinuses reach half-way to the midrib; *pinnately parted*, when they extend almost to the midrib (Fig. 262); and *pinnately divided*, when they reach the midrib, dividing the parenchyma into separate portions (Fig. 263). A few subordinate modifications are indicated by special terms: thus, a pinnatifid or pinnately parted leaf, with regular, very close and narrow divisions, like the teeth of a comb, is said to be *pectinate*; a feather-veined leaf, more or less pinnatifid, but with the lobes decreasing in size towards the base, is

FIG. 260-267. Pinnately and palmately lobed, cleft, parted, and divided leaves.

termed *lyrate*, or *lyre-shaped* (Fig. 278); and a lyrate leaf with sharp lobes pointing towards the base, as in the Dandelion (Fig. 279), is called *runcinate*. A palmately veined leaf is in like manner said to be *palmately lobed* (Fig. 264), *palmately cleft* (Fig. 265), *palmately parted* (Fig. 266), or *palmately divided* (Fig. 267), according to the degree of division. The term *palmate* was originally employed to designate a leaf more or less deeply cut into about five spreading lobes, bearing some resemblance to a hand with the fingers spreading; and it is still used to designate a palmately lobed leaf, without reference to the depth of the sinuses. A palmate leaf with the lateral lobes cleft into two or more segments is said to be *pedate* (Fig. 249), from a fancied resemblance to a bird's foot. By designating the number of the lobes in connection with the terms which indicate their extent and their disposition, botanists are enabled to describe all these modifications with great brevity and precision. Thus, a *palmately three-parted* leaf is one of the radiated-veined kind, which is divided almost to the base into three segments (Fig. 266); a *pinnately five-parted* leaf is one of the feather-veined kind cut into five lobes (two on each side, and one terminal), with the sinuses extending almost to the midrib: and the same plan is followed in describing cleft, lobed, or divided leaves.

284. The segments of a lobed or divided leaf may be again divided, lobed, or cleft, in the same way as the original blade, and the same terms are employed in describing them. Sometimes both the primary, secondary, and even tertiary divisions are defined by a single word or phrase; as *bipinnatifid* (Fig. 280), *tripinnatifid*, *bipinnately parted*, *tripinnately parted*, *twice palmately parted*, &c.

285. Parallel-veined or nerved leaves would naturally be expected to present entire margins, and this they almost universally do when the nerves are convergent (Fig. 230, 243). Such leaves are often lobed or cleft when the principal nerves diverge greatly, as in the Dragon Arum; but the lobes themselves are entire.



286. There are a few terms employed in describing the apex of a leaf, which may be here enumerated. When a leaf tapers to a

FIG. 268-276. Forms of the apex of leaves.

narrowed or slender apex, it is said to be *acuminate* (Fig. 268) : when it terminates in an acute angle, it is said to be *acute* (Fig. 269) : when the apex is an obtuse angle, or rounded, it is termed *obtuse* (Fig. 270) : an obtuse leaf, with the apex slightly indented or depressed in the middle, is said to be *retuse* (Fig. 272), or, if more strongly notched, *emarginate* (Fig. 273) : an obovate leaf with a wider and more conspicuous notch at the apex is termed *obcordate* (Fig. 274), being a cordate or heart-shaped leaf inverted. When the apex is, as it were, cut off by a straight transverse line, the leaf is said to be *truncate* (Fig. 271) : when abruptly terminated by a small and slender projecting point, it is *mucronate* (Fig. 276) : when tipped with a stronger and rigid projecting point, or *cuspidate*, it is *cuspidate* (Fig. 275).

287. All these terms are equally applicable to expanded surfaces of every kind, such as petals, sepals, &c. : and those terms which are used to describe the modifications of solid bodies, such as stems and stalks, are equally applicable to leaves when these affect similar shapes, as they sometimes do.

288. The whole account, thus far, relates to SIMPLE LEAVES, namely, to those which have a blade of one piece, however cleft or lobed, or, if divided, where the separate portions are neither raised on

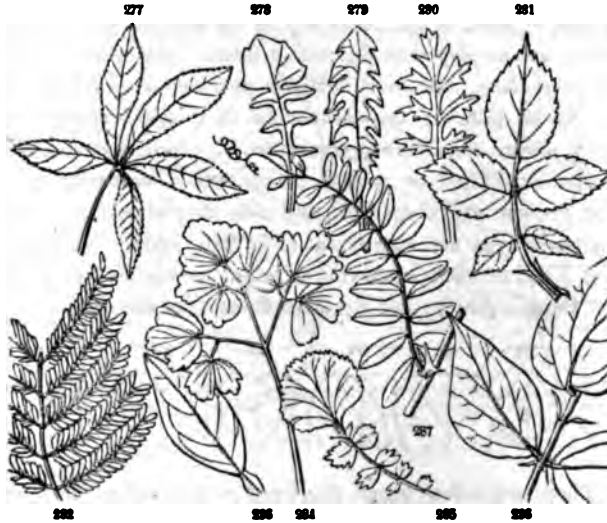


FIG. 277-287. Various forms of lobed and compound leaves.

stalklets of their own, nor *articulated* (by a joint) with the main petiole, so that the pieces are at length detached and fall separately. The distinction, however, cannot be very strictly maintained; there are so many transitions between simple and

289. Compound Leaves. These have the blade divided into entirely separate pieces; or, rather, they consist of a number of blades, borne on a common petiole, usually supported on stalklets of their own, between which and the main petiole an articulation or joint is formed, more or less distinctly. These separate blades are called **LEAFLETS**: they present all the diversities of form, outline, or division which simple leaves exhibit; and the same terms are employed in characterizing them. Having the same nature and origin as the lobes or segments of simple leaves, they are arranged in the same ways on the common petiole. Compound leaves accordingly occur under two general forms, the *pinnate* and the *palmate* (otherwise called *digitate*).

290. The *pinnate* form is produced when a leaf of the pinnately veined sort becomes compound; that is, the leaflets are situated along the sides of the common petiole. There are several modifications of the pinnate leaf. It is *abruptly pinnate*, when the leaflets are even in number, and none is borne on the very apex of the petiole or its branches, as in *Cassia* (Fig. 290), and also in the *Vetch* tribe, where, however, the apex of the petiole is generally



prolonged into a tendril (Fig. 287, 289). It is *impari-pinnate*, or pinnate with an odd leaflet, when the petiole is terminated with a

FIG. 288-290. Simply pinnate.

leaflet (Fig. 281, 288). There are some subordinate modifications; such as *lyrately pinnate*, when the blade of a lyrate leaf (Fig. 278) is completely divided, as in Fig. 285; and *interruptedly pinnate*, when some minute leaflets are irregularly intermixed with larger ones, as is also shown to some extent in the figure last cited. The number of leaflets varies from a great number to very few. When reduced to a small number, such a leaf is said to be *pinnately seven-*, or *five-*, or *tri-foliolate*, as the case may be. A pinnate leaf of three or five leaflets is often called *ternate* or *quinate*; which terms, however, are equally applied to a palmately compound leaf, and also, and more appropriately, to the case of three or five simple leaves growing on the same node. A *pinnately trifoliolate* leaf (Fig. 286) is readily distinguished by having the two lateral leaflets attached to the petiole at some distance below its apex, and by the joint which is observable at some point between their insertion and the lamina of the terminal leaflet. Such a leaf may even be reduced to a single leaflet; as in the Orange (Fig. 283) and the primordial leaves of the common Barberry. This is distinguished from a really simple leaf by the joint at the junction of the partial with the general petiole.

291. The *palmate* or *digitate* form is produced when a leaf of the palmately veined sort becomes compound; in which case the leaflets are necessarily all attached to the apex of the common petiole, as in the Horsechestnut and Buckeye (Fig. 277), and the common Clover (Fig. 304). Such leaves of three, five, or any definite number of leaflets, are termed *palmately* (or *digitately*) *trifoliolate*, *five-foliolate*, &c. A leaf of two leaflets, which rarely occurs, is *unijugate* (one-paired) or *binate*. By this nomenclature, the distinction between pinnately and palmately compound leaves is readily kept up, and every important character of a leaf is expressed with brevity and accuracy.

292. The stalk of a leaflet is called a *partial petiole* (*petiolule*); and the leaflet thus supported is *petiolulate*. The partial petioles may bear a set of leaflets, instead of a single one, when the leaf becomes *doubly* or *twice* compound. Thus a pinnate leaf again compounded in the same way becomes *bipinnate* (Fig. 282), or if still a third time divided it is *tripinnate*, &c. In these cases the main divisions or branches of the common petiole are called *pinnae*, or the pairs *juga*. So a trifoliolate leaf twice compound becomes *biterminate* (Fig. 284); or thrice, *triterminate*, &c. When the primary division

is digitate, the secondary division is often pinnate, thus combining the two modes in the same leaf. A leaf irregularly or indeterminate several times compounded, in whatever mode, is said to be *decompound*.

293. *Leaves of Peculiar Conformation.* The blade of a leaf is almost always symmetrical, that is, the portions on each side of the midrib or axis are similar; but occasionally one side is more developed than the other, when the leaf is *oblique*, as is strikingly the case in the species of *Begonia* (Fig. 246) of our conservatories.

294. *Vertical and Equitant Leaves.* The blade is also commonly horizontal, presenting one surface to the sky, and the other to the earth; in which case the two surfaces differ in structure (262) as well as in appearance, each being fitted for its peculiar offices: if artificially reversed, they spontaneously resume their natural position, or soon perish if prevented from doing so. But in *erect* and *vertical* leaves, the two surfaces are equally exposed to the light, and are similar in structure and appearance. In such erect and *equitant* leaves as those of *Iris* (Fig. 291), it is really the lower surface that is presented to the air; for the leaf is folded together lengthwise (*conduplicate*), and consolidated while in the nascent state, so that the true upper surface is concealed in the interior, except near the base, where they alternately cover over each other in the *equitant* manner (258, Fig. 292). True vertical leaves, which present their edges instead of their surfaces to the earth and sky, generally assume this position by a twisting of the base or the petiole; as is strikingly seen in the *Callistemon* and many other Australian trees of the *Myrtle* family, some of which are now common in green-houses.

295. *Perfoliate Leaves.* While in *Iris* the two halves of the

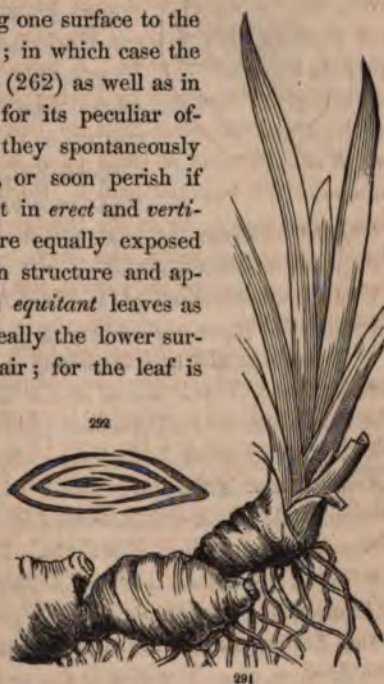


FIG. 291. Equitant erect leaves of *Iris*, with the rootstock.

FIG. 292. A section across these leaves at the base, showing their *equitant* character.

upper surface of a folded leaf cohere, those of some other plants exhibit a cohesion by their contiguous edges, and give rise to a different anomaly.



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This is illustrated by peltate leaves (Fig. 248), and more strikingly by what are termed *perfoliate* leaves. These in some cases originate from the union of the bases of a pair of opposite sessile leaves (*connate-perfoliate*), as in *Silphium perfoliatum*, *Triosteum perfoliatum*, and the upper pairs of true Honeysuckle (Fig. 294). In others they consist of a single clasping leaf, the posterior lobes of

which encompass the stem and cohere on the opposite side, as is seen in *Bupleurum rotundifolium*, *Uvularia perfoliata*, and *Baptisia perfoliata* (Fig. 293).

296. **Leaves with no distinction of Blade and Petiole.** The leaves of the Iris, as well as those of the Daffodil, the Onion, and of many other Endogens, show no

distinction of blade and petiole. In some the leaf of this sort may be regarded as a sessile blade; in others, rather as a petiole performing the functions of a blade. Leaves are not always expanded bodies. Sometimes they are *filiform* or *thread-shaped*, as those of *Asparagus*: some are *acicular*, *acerose*, or *needle-shaped*, as in Pines and Larches (Fig. 212, 213); others are *subulate* or *awl-shaped*, as in Juniper, &c. The Red Cedar and Arbor Vitæ (Fig. 295) exhibit both awl-shaped and *scale-shaped* leaves on different branchlets.

297. **Succulent or Fleshy Leaves**, like those of Stonecrop, House-leek, *Mesembryanthemum* or Ice-Plant, and the Agave or Century-Plant, usually assume shapes more or less unlike ordinary foliage. Some of them are terete, like stems, or at least have no distinct upper and lower surface. These greatly thickened leaves serve a



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FIG. 293. Perfoliate (single) leaves of *Baptisia perfoliata*.

FIG. 294. Connate-perfoliate leaves of a wild Honeysuckle (*Lonicera flava*).

double purpose, being not only organs for assimilation, — the general office of foliage, — but also repositories in which assimilated matter is stored up, just as in the root of the Beet and Radish (Fig. 138), or in subterranean stems or branches in rootstocks, tubers, and corms (188–190, 194). The bases of those leaves which form the scales of bulbs (191) are turned to the same use. In Fig. 176 we have a leaf the blade of which acts as foliage in the ordinary manner of leaves, while its subterranean thickened base serves as a repository of nutriment which the blade has elaborated. The very first leaves of the plant, viz. the cotyledons or seed-leaves (120–123) are commonly subservient to this purpose, and sometimes to no other, as in the Pea, Horsechestnut, Oak, &c.

(124), where these leaves are mere repositories of food for the use of the germinating plant.

298. Leaves as Bud-scales, &c. (161) exhibit the same organ under a different modification, and subserving a different special purpose. Of the same nature are the degenerated or abortive scale-like leaves on the vernal stems of perennial herbs near or beneath the surface of the ground, and on Asparagus shoots, and also those scales which colored parasitic plants produce in place of foliage (152). The primary leaves of Pines are all thin and dry bud-scales; the actual foliage originating from a branch in the axil of each (Fig. 212).

299. Leaves as Tendrils are seen in the proper Pea tribe; where however only the extremity of the common petiole is transformed in this manner (Fig. 287, 289); but in one plant of the kind (*Lathyrus Aphaca*) the whole leaf becomes a tendril.

300. Leaves as Spines occur in several plants. The primary leaves



FIG. 295. A twig of American Arbor Vitæ, exhibiting both awl-shaped and scale-shaped leaves.

FIG. 296. A summer shoot of the Barberry, showing a lower leaf in the normal state; the next partially, those still higher completely, transformed into spines.

of the shoots of the common Barberry offer a familiar instance of the kind (Fig. 296). The most extraordinary modification of the leaf occurs in the

301. Fly-traps of *Dionæa muscipula*, the Venus's Fly-trap of North Carolina (which is found only in the vicinity of Wilmington, where it abounds in wet and sandy bogs). Each



leaf of this most curious plant bears at its summit an appendage (answering, perhaps, to the proper blade), which opens and shuts: fringed with strong bristles or slender teeth on its margin, it bears some resemblance to a steel-trap, and operates much like one. For when open, as it commonly is when the sun shines, no sooner does a fly alight on its surface, and brush against any one of the several long bristles that grow there, than the trap suddenly closes, often capturing the intruder, pressing it all the harder for its struggles, and commonly depriving it of life. After all movement has ceased within, the trap slowly opens, and is ready for another capture. Why this plant catches insects, we are unable to say; and as to the mechanism of the movement it is no more and no less explicable than the much slower movements of ordinary leaves in changing their position.

FIG. 297. A plant of *Dionæa muscipula*, reduced in size. 298. Three of the leaves, nearly the natural size; one of them open, the others closed.

302. *Ascidia* or Pitchers, or tubes open at the summit, represent another remarkable form of leaves. These occur in several plants of widely different families. If we conceive the margins of the dilated part of the leaf of *Dionæa* to curve inwards until they meet, and cohere with each other, there would result a leaf in form not unlike that of *Sarracenia purpurea*, the common Pitcher-plant or Sidesaddle Flower of the Northern United States (Fig. 300). So



the tube or pitcher has been supposed to answer to the petiole, and the hood at the summit to the blade. And this view is strengthened by a Pitcher-plant of the same family (*Heliamphora*, Fig. 299), discovered by Mr. Schomburgk in the mountains of British Guiana, in which the pitcher is not always completed quite to the summit, and the hood is represented by a small concave terminal appendage. In the curious *Nepenthes* (Fig. 301), the petiole is first dilated into a kind of lamina, then contracted into a tendril, and finally dilated into a pitcher, containing fluid secreted by the plant itself; the orifice being accurately closed by a lid, which from analogy was supposed to represent the real blade of the leaf. The study of the development, however (recently made by Dr. Hooker), does not confirm this hypothesis. The whole pitcher of *Nepenthes* is only an anomalous appendage of the tendril-like prolongation of the midrib of the real blade of the leaf. A new Pitcher-plant of the *Sarracenia* family (the *Darlingtonia*), discovered by Mr. Brackenridge in California,

FIG. 299. Pitchers of *Heliamphora*; 300, of *Sarracenia purpurea*; 301, of *Nepenthes*. 302. A phyllodium of a New Holland *Acacia*. 303. The same, bearing a reduced compound blade.

has recently been made known by Dr. Torrey. In this the enlarged summit of the tube is strongly arched like a hood (as in *Sarracenia psittacina* of the Southern States), and is abruptly terminated by a singular two-lobed foliaceous appendage, resembling the forked tail of a fish.

303. The Petiole, or Leafstalk, is usually either round, or half-cylindrical and channelled on the upper side. But in the Aspen, it is strongly flattened at right angles with the blade, so that the slightest breath of air puts the leaves in motion. It is not unfrequently furnished with a leaf-like border, or ring; which, in the Sweet Pea of the gardens, extends downward along the stem, on which the leaves are then said to be *decurent*; or the stalk or stem thus bordered is said to be *alate* or *winged*. In many Umbelliferous plants, the petiole is dilated below into a broad and membranaceous inflated sheath; and in a great number of Endogenous plants the petiole consists of a *sheath*, embracing the stem, which in Grasses is furnished at the summit with a membranous appendage, in some sort equivalent to the stipules, called the *ligule* (Fig. 237). The woody and vascular tissue runs lengthwise through the petiole, in the form usually of a definite number of parallel threads, to be ramified in the blade. The ends of these threads are apparent on the base of the leafstalk when it falls off, and on the scar left on the stem, as so many round dots (Fig. 153, *b*), of a uniform number and arrangement in each species.

304. Phyllodia (Fig. 302, 303). Occasionally the whole petiole dilates into a kind of blade, traversed by ribs, mostly of the parallel-veined kind. In these cases the proper blade of the leaf commonly disappears; this substitute, called a *Phyllodium* (meaning a leaf-like body), taking its place. These phyllodia constitute the whole foliage of the numerous Australian Acacias. Here they are at once distinguished from leaves with a true blade by being entire and parallel-veined; while their proper leaves (of which the earlier ones uniformly appear in germination, and also later ones in casual instances) are compound and netted-veined. They are also to be recognized by their uniformly vertical position, presenting their margins instead of their surfaces to the earth and sky; and they sometimes bear a true compound lamina at the apex, as in Fig. 303.

305. Stipules (259, Fig. 229) are lateral appendages of leaves, usually appearing as small foliaceous bodies, one on each side of the base of the petiole. They are not found at all in a great number of

plants; but their presence or absence is usually uniform throughout a natural order. Stipules assume a great variety of forms analogous to those of the blade. Like it they are sometimes membranaceous or scale-like, and sometimes transformed into spines, as in the Locust-tree, &c. They are sometimes present on developing shoots only; as in the Beech, the Fig, and the Magnolia (Fig. 155, 156), where they form the covering of the buds, but fall away as the leaves expand. They have a strong tendency to cohere with each other, or with the base of the petiole. Thus, in the Clover (Fig. 304), the Strawberry, and the Rose (Fig. 281), a stipule adheres to each side of the base of the petiole; in the Plane-tree, the two are free from the petiole, but cohere by their outer margins, so as to form an apparently single stipule opposite the leaf. In other cases, both margins are united, forming a sheath around the stem, just above the leaf: these are called *intrafoliaceous* stipules; and when membranaceous, as in *Polygonum* (Fig. 305), they have been termed *ochreae*. When opposite leaves have stipules, they usually occupy the space between the petioles on each side, and are termed *interpetiolar*. The stipules of each leaf (one on each side), being thus placed in contact, frequently unite



so as to form apparently but a single pair of stipules for each pair of leaves; instances of which are very common in the order Rubiaceæ.

306. Leaves furnished with stipules are said to be *stipulate*: when destitute of them, *exstipulate*. The leaflets of compound leaves are sometimes provided with small stipules (termed *stipelles*) of their own, as in the Bean (Fig. 286); when they are said to be *stipellate*.

FIG. 304. A leaf of Red Clover, with its three leaflets at the summit of the leafstalk, to which at the base the stipules (*st*) are adherent, one on each side.

FIG. 305. Part of a leaf of *Polygonum orientale*, with its stipules united into a sheath (*ochrea*) and surrounding the stem.

SECT. III. THE DURATION OF LEAVES, AND THE GENERAL ACTION OF FOLIAGE.

307. LEAVES last only for a limited period, and are thrown off, or else perish and decay on the stem, after having fulfilled their office for a certain time.

308. *Duration of Leaves.* In view of their duration, leaves are called *fugacious*, when they fall off soon after their appearance; *deciduous*, when they last only for a single season; and *persistent*, when they remain through the cold season, or other interval during which vegetation is interrupted, and until after the appearance of new leaves, so that the stem is never leafless; as in *Evergreens*.

309. Leaves last only for a single year in many Evergreens, as well as in deciduous-leaved plants; the old leaves falling soon after those of the ensuing season are expanded, or, if they remain longer, ceasing to bear any active part in the economy of the vegetable, and soon losing their vitality altogether. In Pines and Firs, however, although there is an annual fall of leaves either in autumn or spring, yet these were the produce of some season earlier than the last; and the branches are continually clothed with the foliage of from two to five, or even eight or ten, successive years. On the other hand, it is seldom that all the leaves of an herb endure through the whole growing season, the earlier foliage near the base of the stem perishing while fresh leaves are still appearing above. In our deciduous trees and shrubs, however, the leaves of the season are mostly developed within a short period, and they all perish nearly at the same time. They are not destroyed by frost, as is commonly supposed; for they begin to languish, and often assume their autumnal tints (as happens with the Red Maple especially), or even fall, before the earlier frosts; and when vernal vegetation is destroyed by frost, the leaves blacken and wither, but do not fall off entire, as they do in autumn. Some leaves are cast off, indeed, while their tissues have by no means lost their vitality. Death is often rather a consequence than the cause of the fall. Others die and decay on the stem without falling, as in Palms and most Endogens. In some cases many of the dead leaves hang on the branches through the winter, as in the Beech, falling only when the new buds expand, the following spring. We

must therefore distinguish between the death and the fall of the leaf.

310. The Fall of the Leaf is owing to an organic separation, through an *articulation*, or joint, which forms between the base of the petiole and the surface of the stem on which it rests. The formation of the articulation is a vital process, a kind of disintegration of a transverse layer of cells, which cuts off the petiole by a regular line, in a perfectly uniform manner in each species, leaving a clean scar at the insertion (Fig. 153, 155). The solution of continuity begins in the epidermis, where a faint line marks the position of the future joint while the leaf is still young and vigorous: later, the line of demarcation becomes well marked, internally as well as externally; the disintegrating process advances from without inwards, until it reaches the woody bundles; and the side next the stem, which is to form the surface of the scar, has a layer of cells condensed into what appears like a prolongation of the epidermis, so that, when the leaf separates, "the tree does not suffer from the effects of an open wound." "The provision for the separation being once complete, it requires little to effect it; a desiccation of one side of the leafstalk, by causing an effort of torsion, will readily break through the small remains of the fibro-vascular bundles; or the increased size of the coming leaf-bud will snap them; or, if these causes are not in operation, a gust of wind, a heavy shower, or even the simple weight of the lamina, will be enough to disrupt the small connections and send the suicidal member to its grave. Such is the history of the fall of the leaf. We have found that it is not an accidental occurrence, arising simply from the vicissitudes of temperature and the like, but a regular and vital process, which commences with the first formation of the organ, and is completed only when that is no longer useful; and we cannot help admiring the wonderful provision that heals the wound even before it is absolutely made, and affords a covering from atmospheric changes before the part can be subjected to them." * Leaves fall by an articulation in most Exogenous plants, where the insertion usually occupies only a moderate part of the circumference of the stem, and especially in those with woody stems which continue to increase in diameter. When they are not cast off in autumn, therefore, the disruption inevitably takes place the next spring, or whenever the circumfer-

* Dr. Inman, in *Henfrey's Botanical Gazette*, Vol. 1. p. 61.

ence further enlarges. But in most Endogenous plants, where the leaves are scarcely, if at all, articulated with the stem, which increases little in diameter subsequent to its early growth, they are not thrown off, but simply wither and decay; their dead bases or petioles being often persistent for a long time.

311. *The Death of the Leaf*, however, in these and other cases, is still to be explained. Why have leaves such a temporary existence? Why in ordinary cases do they last only for a single year, or a single summer? An answer to this question is to be found in the anatomical structure of the leaf, and the nature and amount of the fluid which it receives and exhales. The water continually absorbed by the roots dissolves, as it percolates the soil, a small portion of earthy matter. In limestone districts especially, it takes up a sensible quantity of carbonate and sulphate of lime, and becomes *hard*. It likewise dissolves a smaller proportion of silex, magnesia, potash, &c. A part of this mineral matter (44, 93) is at once deposited in the woody tissue of the stem; but a larger portion is carried into the leaves, where, as the water is exhaled pure, all this earthy substance, not being volatile, must be left behind to incrust the delicate cells of the parenchyma, much as the vessels in which water is boiled for culinary purposes are in time incrustated with an earthy deposit. This earthy incrustation, in connection with the deposition of organic solidified matter, must gradually choke the tissue of the leaf, and finally unfit it for the performance of its offices. Hence the fresh leaves most actively fulfil their functions in spring and early summer; but languish towards autumn, and ere long inevitably perish. Hence, although the roots and branches may be permanent, the necessity that the leaves should be annually renewed. But the former are, in fact, annually renewed likewise; and life abandons the annual layers of wood and bark almost as soon as it does the leaves they supply (224, 231), and for similar reasons; although their situation is such that they become part of a permanent structure, and serve to convey the sap, even when no longer endowed with vitality.

312. The general correctness of this view may be tested by direct microscopical observation. In Fig. 223, 224, some superficial parenchyma thus obstructed by long use is represented; and similar illustrations may be obtained from ordinary leaves. That this deposit consists in great part of earthy matter, is shown by carefully burning away the organic materials of an autumnal leaf over

a lamp, and examining the ashes by the microscope; which will be found very perfectly to exhibit the form of the cells. The ashes which remain when a leaf or other vegetable substance is burned in the open air, represent the earthy materials which it has accumulated. A vernal leaf leaves only a small quantity of ashes; an autumnal leaf yields a very large proportion,—from ten to thirty times as much as the wood of the same species; although the leaves contain the deposit of a single season only, while the heart-wood is loaded with the accumulations of successive years.*

313. *Exhalation from the Leaves.* The quantity of water exhaled from the leaves during active vegetation is very great. In one of the well-known experiments of Hales, a Sunflower three and a half feet high, with a surface of 5,616 square inches exposed to the air, was found to perspire at the rate of twenty to thirty ounces avoirdupois every twelve hours, or seventeen times more than a man. A Vine, with twelve square feet of foliage, exhaled at the rate of five or six ounces a day; and a seedling Apple-tree, with eleven square feet of foliage, lost nine ounces a day. The amount varies with the degree of warmth and dryness of the air, and of exposure to light; and is also very different in different species, some exhaling more copiously even than the Sunflower. But when we consider the vast perspiring surface presented by a large tree in full leaf, it is evident that the quantity of watery vapor it exhales must be immense. This exhalation is dependent on the capacity of the air for moisture at the time, and upon the presence of the sun; often it is scarcely perceptible during the night. The Sunflower, in the experiment of Hales, lost only three ounces in a warm, dry night, and underwent no diminution during a dewy night.

314. *Rise of the Sap.* Now this exhalation by the leaves requires a corresponding absorption by the roots. The one is the measure of the other. If the leaves exhale more in a given time than the roots can restore by absorption from the soil, the foliage droops; as we see in a hot and dry summer afternoon, when the drain by

* The dried leaves of the Elm contain more than eleven per cent of ashes, while the wood contains less than two per cent; those of the Willow, more than eight per cent, while the wood has only 0.45; those of the Beech, 6.69, the wood only 0.36; those of the (European) Oak, 4.05, the wood only 0.21; those of the Pitch-Pine, 3.15, the wood only 0.25 per cent. Hence the decaying foliage in our forests restores to the soil a large proportion of the inorganic matter which the trees from year to year take from it.

exhalation is very great, while a further supply of moisture can hardly be extorted from the parched soil ; — as we observe also in a leafy plant newly transplanted, where the injured rootlets are not immediately in a fit condition for absorption. Ordinarily, however, exhalation by the leaves and absorption by the roots are in direct ratio to each other, and the loss sustained by the leaves is immediately restored (by endosmosis, 40) through the ascent of the sap from the branches, the latter being constantly supplied by the stem ; so that, during active vegetation, the sap ascends from the remotest rootlets to the highest leaves, at a rate corresponding to the amount of exhalation. The action of the leaves is, therefore, the principal mechanical cause of the ascent of the sap. This is well illustrated when a graft has a different time of leafing from that of the stock upon which it is made to grow, the graft wholly regulating the season or temperature at which the sap is put in motion, and controlling the habits of the original stock. Also by introducing the branches of a tree into a conservatory during winter ; when, as their buds expand, the sap in the trunk without is set unseasonably into motion to supply the demand.

315. During the summer's vegetation, while the sap is consumed or exhaled almost as fast as it enters the plant, no considerable accumulation can take place : but in autumn, when the leaves perish, the rootlets, buried in the soil beyond the influence of the cold, which checks all vegetation above ground, continue for a time slowly to absorb the fluid presented to them. Thus the trunks of many trees are at this season gorged with sap, which will flow from incisions made into the wood. This sap undergoes a gradual change during the winter, and deposits its solid matter in the cells of the wood. The absorption recommences in the spring, before new leaves are expanded to consume the fluid ; chemical changes take place ; the soluble matters in the tissue of the stem are redissolved, and the trunk is consequently again gorged with sap, which will flow, or *bleed*, when wounded. But when the leaves resume their functions, or when flowers are developed before the leaves appear, as in many forest-trees, this stock of rich sap is rapidly consumed, and the sap will no longer flow from an incision. It is not, therefore, at the period when the trunk is most gorged with sap, in spring and autumn, but when least so, during summer, that the sap is probably most rapidly ascending.

CHAPTER VI.

OF THE FOOD AND NUTRITION OF PLANTS.

SECT. I. THE GENERAL PHYSIOLOGY OF VEGETATION.

316. THE Organs of Vegetation or Nutrition (those by which plants grow and form their various products) having now been considered, both as to their structure and to some extent as to their action, we are prepared to take a comprehensive survey of the general results of vegetation; to inquire into the elementary composition of plants, the nature of the food by which they are nourished, the sources from which this food is derived, and the transformations it undergoes in their system. It is in vegetable digestion, or, to use a better term, in *assimilation*, that the essential nature of vegetation is to be sought, since it is in this process alone that mineral, unorganized matter is converted into the tissue of plants and other forms of organized matter (1, 12-16). From this point of view, therefore, the reciprocal relations and influences of the mineral, vegetable, and animal kingdoms may be most advantageously contemplated, and the office of plants in the general economy of the world best understood. This portion of general physiology is intimately connected with chemistry, and some knowledge of that science is requisite for understanding it. We are here restricted to the bare statement of the leading facts which are thought to be established, and the more important deductions which may be drawn from them.

317. While the organs of vegetation have been considered anatomically and morphologically, or in view of their structure and development, still the leading points of their physiology, or connected action in the life and growth of the plant, have from time to time been explained or assumed.

318. The functions of nutrition, which, in the higher animals, comprise a variety of distinct processes, are reduced to the greatest degree of simplicity in vegetables. *Imbibition*, *assimilation*, and *growth* essentially include the whole.

319. Plants absorb their food, entirely in a liquid or gaseous form, by imbibition, according to the law of endosmosis (40), through the

walls of the cells that form the surface, principally those of the newest roots and their fibrils (133). The fluid absorbed by the roots, mingled in the cells with some previously assimilated matter they contain in solution (26, 79), is diffused by exosmosis and endosmosis from cell to cell, rising principally in the wood (224, 230); and is attracted into the leaves (or to other parts of the surface of the plant exposed to the air and light) by the exhalation which takes place from them (314), and the consequent inspissation of the sap. Here, exposed to the light of the sun, the crude sap is assimilated, or converted into organizable matter (79); and, thus prepared to form vegetable tissue or any organic product, the elaborated fluid is attracted into growing parts by endosmosis, in consequence of its consumption and condensation there, or is diffused through the newer tissues. There is no movement in plants of the nature of the circulation in animals. Even in the so-called vessels of the latex there is merely a mechanical flow from the turgid tubes towards the place where the liquid is escaping when wounded, or from a part placed under increased pressure (63). The only circulation, or directly vital movement of fluid, in vegetable tissue, is the cyclosis, or the system of currents in the layer of protoplasm in young and active cells (36): this movement is confined to the individual cell, and can have no influence in the transference of the sap from cell to cell. Respiration is likewise a function of animals alone. What is generally so called in vegetables is connected with assimilation, and is of entirely different physiological significance, as will presently be shown. None of the secretions of plants appear, like many of those of animals, to play any part, at least any essential part, in nutrition. Many, if not all of them, are purely chemical transformations of the general assimilated products of plants, — are *excretions* rather than secretions (88–90).

320. The appropriation of assimilated matter in vegetable growth, and the production and multiplication of cells, which make up the fabric of the plant, have already been treated of (25–34). We have now mainly to consider what the food of plants is, whence it is derived, and how it is elaborated.

SECT. II. THE FOOD AND THE ELEMENTARY COMPOSITION OF PLANTS.

321. The Food and the elementary composition of plants stand in a necessary relation to each other. Since it is not to be supposed that plants possess the power of creating any simple element, whatever they consist of must have been derived from without. Their *composition* indicates their *food*, and *vice versâ*. If we have learned the chemical composition of a vegetable, and also what it gives back to the soil and the air, we know consequently what it must have derived from without, that is, its *food*. Or, if we have ascertained what the plant takes from the soil and air, and what it returns to them, we have learned its chemical composition, namely, the difference between these two. And when we compare the nature and condition of the materials which the plant takes from the soil and the air with what it gives back to them, we may form a correct notion of the influence of vegetation upon the mineral kingdom. By considering the materials of which plants are composed, we may learn what their food must necessarily contain.

322. The Constituents of Plants are of two kinds; the *earthy* or *inorganic*, and the *organic*. It has been stated (93) that various earthy matters, dissolved by the water which the roots absorb, are drawn into the plant, and at length deposited in the wood, leaves, &c. These form the ashes which are left on burning a leaf or a piece of wood. Although these mineral matters are often turned to account by the plant, and some of them are necessary in the formation of certain products, (as the siliceous matter which gives needful firmness to the stalk of Wheat, and the phosphates which are found in the grain,) yet none of them are essential to simple vegetation, which may, to a certain extent, proceed without them. These materials, the presence of which is in some sort accidental, although for certain purposes essential, are distinguished as the *earthy*, or *mineral*, or *inorganic constituents* of plants. This class may be left entirely out of view for the present. But the analysis of any newly formed vegetable tissue, or of any part of the plant, such as a piece of wood, after the incrusting mineral matter has been chemically removed, invariably yields but three or four elements. These, which are indispensable to vegetation, and make up at least from eighty-eight to ninety-nine per cent of every vege-

table substance, are termed the *universal, organic constituents* of plants. They are Carbon, Hydrogen, Oxygen, and Nitrogen (10, 27). The proper vegetable structure, that is, the tissue itself, consists of only three of these elements, namely, carbon, hydrogen, and oxygen; while the fourth, nitrogen, is an essential constituent of the protoplasm, which plays so important a part in the formation of the cells and is an element of one class of vegetable products.

323. *The Organic Constituents.* These four elements must be furnished by the food upon which the vegetable lives;—they must be drawn from the soil and the air; in some cases, doubtless, from the latter source, as in Epiphytes, or Air-plants (149), but generally and principally by absorption through the roots. The plant's nourishment is wholly received either in the gaseous or the liquid form; for the leaves can imbibe air or vapor only, and the roots are incapable of taking in particles of solid matter, however minutely divided (40, 133).

324. In whatever mode imbibed, evidently the main vehicle of the plant's nourishment is *water*, which as a liquid or as vapor is continually in contact with its roots, and in the state of vapor always surrounds its leaves. We have seen how copiously water is taken up by the growing plant, and have formed some general idea of its amount by the quantity that is exhaled unconsumed by the leaves (313). But pure water, although indispensable, is insufficient for the nourishment of plants. It consists of oxygen and hydrogen; and therefore may furnish, and doubtless does principally furnish, these two essential elements of the vegetable structure. But it cannot supply what it does not itself contain, namely, the carbon and nitrogen which the plant also requires.

325. Yet the question arises, whether the water which the plant actually imbibes contains in fact a quantity of these remaining elements. Though pure water cannot, may not *rain-water* supply the needful carbon and nitrogen? It is evident that, if the water which in such large quantities rises through the plant, and is exhaled from its leaves, contain even a very minute quantity of these ingredients, in such a form that they may be detained when the superfluous water is exhaled, this might furnish the whole organic food of the vegetable; since the plant may condense and accumulate the carbon and nitrogen, just as the extremely minute quantity of earthy matter which the water contains is in time largely accumulated in the leaves and wood.

326. As respects the nitrogen, nearly seventy-nine per cent of the atmosphere consists of this gas in an uncombined or free state, that is, merely mingled with oxygen. And, being soluble to some extent in water, every rain-drop that falls through the air absorbs and brings to the ground a minute quantity of it, which is therefore necessarily introduced into the plant with the water which the roots imbibe. This accounts for the free nitrogen which is always present in plants.

327. The plant also receives nitrogen in the form of ammonia (or hartshorn), a compound of hydrogen and nitrogen, which is always produced when any animal and almost any vegetable substance decays, and which, being very volatile, continually rises into the air from these and other sources. Besides, it appears to be formed in the atmosphere, through electrical action in thunder-storms (in the form of nitrate of ammonia). The extreme solubility of ammonia and all its compounds prevents its accumulation in the atmosphere, from which it is greedily absorbed by aqueous vapor, and brought down to the ground by rain. That the roots actually absorb it may be inferred from the familiar facts, that plants grow most luxuriantly when the soil is supplied with substances which yield much ammonia, such as animal manures; and that ammonia may be detected in the juices of almost all plants. That the ammonia in the air, and the nitre almost everywhere formed in a fertile soil, and not the free nitrogen of the atmosphere, take the principal part in the formation of the protoplasm and other quaternary elements of plants, is demonstrated by Boussingault's experiments, showing that a seedling from which all nitrogen is excluded except the free nitrogen of the air, as it vegetates does not increase the amount of azotized matter it originally had in the seed, but diminishes it.* Rain-water, therefore, contains the third element of vegetation, namely, nitrogen, both in a separate form and in that of ammonia, &c.

328. The source of the remaining constituent, carbon, is still to be sought. Of this element plants must require a copious supply, since it forms much the largest portion of their bulk. If the carbon of a leaf or of a piece of wood be obtained separate from the other organic elements,—which may be done by charring, that is, by heating it out of contact with the air, so as to drive off the oxygen,

* *Comptes Rendus*, November 28, 1853, and *Ann. Sci. Naturelles*, ser. 4, Vol. 1 & 2 (1854); also Vol. 7 (1857), showing the part which nitre plays.

hydrogen, and carbon,—although a small part of the carbon is necessarily lost in the operation, yet what remains perfectly preserves the shape of the original body, even to that of its most delicate cells and vessels. With the exception of the ashes, this consists of carbon, or charcoal, amounting to from forty to sixty per cent, by weight, of the original material. Carbon is itself a solid, absolutely insoluble in water, and therefore incapable of assumption by the plant. The chief, if not the only, fluid compound of carbon which is naturally presented to the plant, is that of carbonic acid gas, which consists of carbon united with oxygen. This gas makes up on the average one 2500th of the bulk of the atmosphere; from which it may be directly absorbed by the leaves. But, being freely soluble in water up to a certain point, it must also be carried down by the rain and imbibed by the roots. The carbonic acid of the atmosphere is therefore the great source of carbon for vegetation.

329. It appears, then, that the atmosphere—considering water in the state of vapor to form a component part of it—contains all the essential materials for the growth of vegetables, and in the form best adapted to their use, namely, in the fluid state. It furnishes water, which is not only food itself, inasmuch as it supplies oxygen and hydrogen, but is likewise the vehicle of the others, conveying to the roots what it has gathered from the air, namely, the requisite supply of nitrogen, either as such or in the form of ammonia, and of carbon in the form of carbonic acid.

330. These essential elements, the whole *proper food* of plants, *may be* absorbed by the leaves directly from the air, in the state of gas or vapor. Doubtless most plants actually take in no small part of their food in this way. Drooping foliage may be revived by sprinkling with water, or by exposure to a moist atmosphere. A vigorous branch of the common Live-for-ever (*Sedum Telephium*), or of many similar plants, it is well known, will live and grow for a whole season when pinned to a dry and bare wall; and the Epiphytes, or Air-plants (149), as they are aptly called, must derive their whole sustenance immediately from the air; for they have no connection with the ground. That leaves absorb carbonic acid directly from the air is readily shown (348).

331. But, as a general statement, it may be said that plants, although they derive their food from the air, receive it mainly through their roots. The *aqueous vapor*, condensed into rain or dew, and

bringing with it to the ground a portion of *carbonic acid*, and of *nitrogen* or *ammonia*, &c., supplies the appropriate food of the plant to the rootlets (sometimes in a liquid, but also much of it in a gaseous form). Imbibed by these, it is conveyed through the stem and into the leaves, where the superfluous water is restored to the atmosphere by exhalation,* while the residue is converted into the proper nourishment and substance of the vegetable.

§32. The atmosphere is therefore the great storehouse from which vegetables derive their nourishment; and it might be clearly shown that all the constituents of plants, excepting the small earthy portion that many can do without, have at some period formed a part of the atmosphere. The vegetable kingdom represents an amount of matter, which plants have withdrawn from the air, organized, and confined for a time to the surface.

§33. Does it therefore follow, that the soil merely serves as a foothold to plants, and that all vegetables obtain their whole nourishment directly from the atmosphere? This must have been the case with the first plants that grew, when no vegetable or animal matter existed in the soil; and no less so with the first vegetation that covers small volcanic islands raised in our own times from the sea, or the surface of lava thrown from ordinary volcanoes. No vegetable matter is brought to these perfectly sterile mineral soils, except the minute portion contained in the seeds wafted thither by winds or waves. And yet in time a vast quantity is produced, which is represented not only by the existing vegetation, but by the mould that the decay of previous generations has imparted to the soil. We arrive at the same result by the simple experiment of causing a

* The water exhaled may be again absorbed by the roots, laden with a new supply of the other elements from the air, again exhaled, and so on; as is beautifully illustrated by the cultivation of plants in closed *Ward cases*, where plants are seen to flourish for a long time with a very limited supply of water, every particle of which (except the small portion actually consumed by the plants) must pass repeatedly through this circulation. This vegetable microcosm well exhibits the actual relations of water, &c. to vegetation on a large scale in nature; where the water is alternately and repeatedly raised by evaporation and recondensed to such extent that what actually falls in rain is estimated to be re-evaporated and rained down (on an average throughout the world) ten or fifteen times in the course of a year. In this way the atmosphere is repeatedly washed by the rain; and those vapors washed out which else by their accumulation would prove injurious to men and animals, and conveyed to the roots of plants, which they are especially adapted to nourish.

seed of known weight to germinate on powdered flints, or on a soil which has been heated to redness, and watering it with rain-water alone. When the young plant has attained all the development it is capable of under these circumstances, it will be found to weigh (after due allowance for the silex it may have taken up) perhaps fifty or one hundred times as much as the original seed. There can be no question as to the source of this vegetable matter in all these cases. *The requisite materials exist in the air. Plants possess the peculiar faculty of drawing them from the air. The air must have furnished the whole.* This conclusion is amply confirmed by a great variety of familiar facts; such as the continued accumulation of vegetable matter in peat-bogs, and of mould in neglected fields, in old forests, and generally wherever vegetation is undisturbed. Since this rich mould, instead of diminishing, regularly increases with the age of the forest and the luxuriance of vegetation, the trees must have drawn from the air, not only the vast amount of carbon, &c. that is stored up in their trunks, but an additional quantity which is imparted to the soil in the annual fall of leaves, &c.

334. Still it by no means follows that each plant draws all its nourishment directly from the air. This unquestionably happens in some of the special cases just mentioned; with Air-plants, and with those that first vegetate on volcanic earth, bare rocks, naked walls, or pure sand. But it is particularly to be remarked, that only certain tribes of plants will continue to live under such circumstances, and that none of the vegetables most useful as food for man or the higher animals will thus thrive and come to maturity. In nature, the races of plants that will grow at the entire expense of the air, such as Lichens, Mosses, Ferns, and certain tribes of succulent Flowering plants, gradually form a soil of vegetable mould during their life, which they increase in their decay; and the successive generations live more vigorously upon the inheritance, being supported partly upon what they draw from the air, and partly upon the ancestral accumulation of vegetable mould. Thus, each generation may enrich the soil, even when consisting of plants that draw largely upon vegetable matter thus accumulated; for these annually restore a portion by their dead leaves, &c., and when they die they may bequeath to the soil, not only all that they took from it, but all that they drew from the air. It is in this way that the lower tribes and so-called useless plants create a soil, which will in time support the higher plants, of immediate importance to

man and the higher animals, but which could never grow and perfect their fruit, if left, like their humble but indispensable predecessors, to derive an unaided subsistence directly from the inorganic world. While it is strictly true, therefore, that all the organic elements have been originally derived from the air, it is not true that what is contained in almost any given plant, or in any one crop, is immediately drawn from this source. A part of it is thus supplied, but in proportions varying greatly in different species and under different circumstances. Undisturbed vegetation consequently tends always to enrich the soil. But in agriculture the crop is ordinarily removed from the land, and with it not only what it has taken from the earth, but also what it has drawn from the air; and the soil is accordingly impoverished. Hence the farmer finds it necessary to follow the example of nature, and to restore to the land, in the form of manure, an amount substantially equivalent to what he takes away.

335. The mode in which vegetable mould is turned to account by growing plants has not yet been sufficiently investigated. According to Liebig, the decaying vegetable matter is not employed until it has been resolved into its original inorganic elements, namely, into water, carbonic acid, ammonia, &c.; which are imbibed by the roots both directly in the gaseous state, and when taken up by the water as it percolates through the soil.* Others suppose that a portion of the food which plants derive from decaying vegetable matter may consist of soluble, still organic compounds. The economy of the greenless parasitic plants (152) is adduced in confirmation of this view: but these are nourished by the foster plant just as its own flowers are nourished. Decisive evidence to the point is furnished by Fungi, the greater part of which live upon decaying organic matter, and have not the power of forming organizable pro-

* While it may be rightly said, that the proportion of carbonic acid in the atmosphere is too minute directly to supply ordinary vegetation, especially that of esculent plants, with sufficient carbon, this cannot be said of the air contained in the pores and crevices of the soil, at least in any fertile soil. This air in the soil contains a far larger proportion of carbonic acid than the atmosphere above; the excess being derived partly by direct absorption or by the action of rain, and in an enriched soil more largely from the decay of the materials of former generations of plants. In a recently manured soil, the carbonic acid ordinarily amounts even to 10 or 20 per cent. See Boussingault and Lewy, in *Ann. Sci. Nat.* ser. 3, Vol. 19, p. 13.

ducts from inorganic materials; and there is reason to think, that some Phænogamous plants (of which our *Monotropa*, or Indian Pipe is one) are nourished in this way.

336. *The Earthy Constituents.* The mineral substances which form the inorganic constituents of plants (322) are furnished by the soil, and are primarily derived from the slow disintegration and decomposition of the rocks and earths that compose it.* These are dissolved, for the most part in very minute proportions, in the water which percolates the soil, (aided, as to the more insoluble earthy salts, by the carbonic acid which this water contains,) and with this water are taken up by the roots. However minute their proportion in the water which the roots imbibe, the plant concentrates and accumulates them, by the exhalation of the water from the leaves, until they amount to an appreciable quantity, often to a pretty large percentage, of the solid matter of the vegetable. As might be expected (312), the leaves contain a much larger amount of ashes, or earthy matter, than the wood, and herbaceous plants more than trees, in proportion to their weight when dry.†

337. The ashes left after combustion are mostly composed of the "alkaline chlorides, with the bases of potash and soda, earthy and metallic phosphates, caustic or carbonate of lime and magnesia, silica, and oxides of iron and of manganese. Several other substances are also met with there, but in quantities so small that they may be neglected." Different species growing in the same soil appear to take in some portion of all such materials as are natu-

* According to Liebig, the quantity of potash contained in a layer of soil formed by the disintegration of 40,000 square feet of the following rocks, &c., to the depth of twenty inches, is as follows. This quantity of Felspar (a large component of granite, &c.) contains 1,152,000 lbs.

Clinkstone,	from 200,000 to 400,000 "
Basalt,	" 47,500 " 75,000 "
Clay-slate,	" 100,000 " 200,000 "
Loam,	" 87,000 " 300,000 "

The siliceous yielded to the soil by the gradual decomposition of granite and other rocks is in the form of a silicate of potash or other alkali, which, though insoluble in pure water, is slowly acted upon and dissolved by the united action of water and carbonic acid, or more largely by water impregnated with carbonate of potash, which is abundantly liberated during the natural decomposition of these rocks.

† The subjoined results, selected from Boussingault, exhibit in a tabular form the relative quantities of organic and inorganic constituents in several kinds of

rally presented to them in solution, but not, however, in the same proportions, nor in proportion to the relative solubility of these several substances; while, on the other hand, the same species in different localities, and also each of its particular parts or organs, contains, or tends to contain, the same mineral constituents in nearly the same proportion. One base, however, is often substituted for another, equivalent for equivalent, as magnesia for lime, soda for potash. The roots, therefore, appear to have a certain power of selection in respect to these mineral materials. Nor is it a valid objection to this view, that they absorb poisons which destroy them. These are either organic products, such as opium; or else are corrosive substances, such as sulphate of copper, which disorganize the rootlets. For mutilated roots or stems absorb all dissolved materials of the proper density that are presented to them, not only in much larger quantity (so long as the cut is fresh) than do uninjured rootlets, but almost indifferently, and in the same proportion that they absorb the water they are dissolved in.

338. In the ashes, only the salts which resist the action of heat, such as the phosphates, sulphates, and hydrochlorates, are in the state in which they existed in the plant itself. A great part of the bases were combined with organic acids, formed in the plant, and most largely with the oxalic (86): these compounds are by incineration, or by exposure to the air, principally converted into carbonates.

339. It being indispensable to its well-being that a plant should find in the soil such mineral matters as are necessary to its growth, we perceive why various species will only flourish in particular soils or situations; why plants which take up common salt, &c. are restricted to the sea-shore and to the vicinity of salt-springs; why

herbage, compared, in several cases, with the root or grain. The water was previously driven off by thorough drying.

[illegible]

numerous weeds which grow chiefly around dwellings, and follow the footsteps of man and the domestic animals, flourish only in a soil abounding in nitrates (their ashes containing a notable quantity either of nitrate of potash or of lime); why the Vine requires alkaline manures, to replace the large amount of tartrate of potash which the grapes contain; and why Pines and Firs, the ashes of which contain very little alkali, will thrive in thin or sterile soils, while the Beech, Maple, Elm, &c., abounding with potash, are only found in strong and fertile land.

340. Where vegetation is undisturbed by man, all these needful earthy materials, which are drawn from the soil during the growth of the herbage or forest, are in time restored to it by its decay, in an equally soluble form, along with organic matter which the vegetation has formed from the air. But in cultivation, the produce is carried away, and with it the materials which have been slowly yielded by the soil. "A medium crop of Wheat takes from one acre of ground about 12 pounds, a crop of Beans about 20 pounds, and a crop of Beets about 11 pounds, of phosphoric acid, besides a very large quantity of potash and soda. It is obvious that such a process tends continually to exhaust arable land of the mineral substances useful to vegetation which it contains, and that a time must come, when, without supplies of such mineral matters, the land would become unproductive from their abstraction. . . . In the neighborhood of large and populous towns, for instance, where the interest of the farmer and market-gardener is to send the largest possible quantity of produce to market, consuming the least possible quantity on the spot, the want of saline principles in the soil would very soon be felt, were it not that for every wagon-load of greens and carrots, fruit and potatoes, corn and straw, that finds its way into the city, a wagon-load of dung, containing each and every one of these principles locked up in the several crops, is returned to the land, and proves enough, and often more than enough, to replace all that has been carried away from it."* The loss must either be made up by such equivalent return, or the land must lie fallow from

* Boussingault, *Economie Rurale*: from the Engl. Trans., p. 493. Further: "It may be inferred that, in the most frequent case, namely, that of arable lands not sufficiently rich to do without manure, there can be no continuous [independent] cultivation without annexation of meadow; in other words, one part of the farm must yield crops without consuming manure, so that this may replace the alkaline and earthy salts which are constantly withdrawn by suc-

time to time until these soluble substances are restored by further disintegration of the materials of the soil: or meanwhile the more exhausting crops may be alternated with those that take least from the soil and most from the air; or with one which, like clover, although it takes up 77 pounds of alkali per acre, may be consumed on the field, so as to restore most of this alkali in the manure for the succeeding crop.

341. It has been asserted that the advantage of preceding a wheat crop by one of Leguminous plants (such as Peas, Clover, Lucerne, &c.), or of roots or tubers, is owing to the fact, that these leave the phosphates, &c. nearly untouched for the wheat which is to follow, and which largely abstracts them. The results of Bous-singault's experiments and analyses show that these products are far from having the deficiency of phosphates which was alleged. "For example, beans and haricots take 20 and 13.7 pounds of phosphoric acid from every acre of land; potatoes and beet-root take 11 and 12.8 pounds of that acid, exactly what is found in a crop of wheat. Trefoil is equally rich in phosphates with the sheaves of corn that have gone before it."* His further re-

cessive harvests from another part. Lands enriched by rivers alone permit of a total and continued export of their produce without exhaustion. Such are the fields fertilized by the inundations of the Nile; and it is difficult to form an idea of the prodigious quantities of phosphoric acid, magnesia, and potash, which, in a succession of ages, have passed out of Egypt with her incessant exports of corn." — p. 503.

* Bous-singault, *l. c.*, p. 497. — Subjoined is a table, from the same work, of the percentage of Mineral Substances taken up from the soil by various plants grown at Bechelbronn.

Substances which yielded the Ashes.	Acids			Chlorine.	Lime.	Magnesia.	Potash.	Soda.	Silica.	Oxide of Iron, Alumina, &c.	Charcoal, Moisture, and Loss.
	Carbonic.	Sulphuric.	Phosphoric.								
Potatoes,	13.4	7.1	11.3	2.7	1.8	5.4	51.5	traces	5.6	0.5	0.7
Mangel-Wurzel,	16.1	1.6	6.1	5.2	7.0	4.4	39.0	6.0	8.0	2.5	4.2
Turnips,	14.0	10.9	6.0	2.9	10.9	4.3	33.7	4.1	6.4	1.2	5.5
Potato-tops,	11.0	2.2	10.8	1.6	2.3	1.8	44.5	traces	13.0	5.2	7.6
Wheat,	0.0	1.0	47.0	traces	2.9	15.9	29.5	traces	1.3	0.0	2.4
Wheat-straw,	0.0	1.0	3.1	0.6	8.5	5.0	9.2	0.3	67.6	1.0	3.7
Oats,	1.7	1.0	14.9	0.5	3.7	7.7	12.9	0.0	53.3	1.3	3.0
Oat-straw,	3.2	4.1	3.0	4.7	8.3	2.8	24.5	4.4	40.0	2.1	2.9
Clover,	25.0	2.5	6.3	2.6	24.6	6.3	26.6	0.5	5.3	0.3	0.0
Peas,	0.5	4.7	30.1	1.1	10.1	11.0	35.3	2.5	1.5	traces	2.3
French beans,	3.3	1.3	26.8	0.1	5.8	11.5	49.1	0.0	1.0	traces	1.1
Horse beans,	1.0	1.6	34.2	0.7	5.1	8.6	45.2	0.0	0.5	traces	3.1

searches seem to show that these crops exhaust the soil less than the cereal grains, in part at least, on account of the large quantity of organic matter, rich in nitrogen, which they leave to be incorporated with the soil. The theory of rotation in crops, founded by De Candolle on the assumption that excretions from the roots of a plant accumulate in the soil until in time they become injurious to that crop, but furnish appropriate food for a different species, is entirely abandoned as an explanation; and even the fact that such excretions are formed, at least to any considerable extent, is not made out. That they could accumulate and remain in the soil without undergoing decomposition is apparently impossible.

SECT. III. ASSIMILATION, OR VEGETABLE DIGESTION, AND ITS RESULTS.

342. WE have reached the conclusion, that the universal food of plants is rain-water, which has absorbed some carbonic acid gas and nitrogen (partly in the form of ammonia or of other compounds) from the air, or dissolved them from the remains of former vegetation in the soil, whence it has also taken up a variable (yet more or less essential) quantity of earthy matter.

343. This fluid, imbibed by the roots, and carried upwards through the stem, receives the name of *sap* or *crude sap* (79). Upon its introduction into the plant, this is at once mingled with some elaborated sap or soluble organized matter it meets with; thus becoming sweet in the Maple, &c., and acquiring different sensible properties in different species. This latter is already elaborated food, and may therefore be immediately employed in vegetable growth. But the crude sap itself is merely raw material, unorganized or mineral matter, as yet incapable of forming a part of the living structure. Its conversion into organized matter constitutes the process of

344. Assimilation, or what, from an analogy with animal life, is usually termed *Vegetable Digestion*. To undergo this important change, the crude sap is attracted into the leaves, or other green parts of the plant, which constitute the apparatus of assimilation, where it is exposed to the light of the sun, under which influence alone can this change be effected. Under the influence of solar light, the fabric is itself constructed, and the *chlorophyll*, or green

matter of plants, upon which, or in connection with which, the light exerts its wonderful action, is first developed. When plants are made to grow in insufficient light, as when potatoes throw out shoots in cellars, this green matter is not formed. When light is withdrawn, it is soon decomposed; as we see when Celery is blanched by heaping the soil around its stems. So, also, the naturally greenless leaves of plants parasitic upon the roots or stems of other species (152) have no direct power of assimilation, but feed upon and grow at the expense of already assimilated matter. But all green parts, such as the cellular outer bark of most herbs, act upon the sap in the same manner as leaves, even supplying their places in plants which produce few or no leaves, as in the Cactus, &c. Under the influence of light, an essential preliminary step in vegetable digestion is accomplished, namely, the concentration of the crude sap by the evaporation or exhalation of the now superfluous water, the mechanism and consequences of which have already been considered (313).

345. We have now to consider the further agency of light in vegetable digestion itself, namely, its action in the leaf upon the concentrated sap. Here it accomplishes two unparalleled results, which essentially characterize vegetation, and upon which all organized existence absolutely depends (1, 16). These are, — 1st. *The chemical decomposition of one or more of the substances in the sap which contain oxygen gas, and the liberation of this oxygen at the ordinary temperature of the air.* The chemist can liberate oxygen gas from its compounds only by powerful reagents, or by great heat. 2d. *The transformation of this mineral, inorganic food into organic matter, — the organized substance of living plants, and consequently of animals.* These two operations, although separately stated, are in fact but different aspects of one great process. We contemplate the first, when we consider what the plant gives back to the air; the second, when we inquire what it retains as the materials of its own growth. The concentrated sap is decomposed; the portion not required in the growth of the plant is returned to the air; and the remaining elements are at the same time rearranged, so as to form peculiar *organic* products.

346. The principal material given back to the air, in this process, is oxygen gas,* that element of our atmosphere which alone

* A small proportion of nitrogen gas is likewise almost constantly exhaled from the leaves; but this appears to come from the nitrogen which the water

renders it fit for the breathing and life of animals. That the foliage of plants in sunshine is continually yielding oxygen gas to the surrounding air has been familiarly known since the days of Ingenhous and Priestley, and may at any moment be verified by simple experiment. The readiest way is, to expose a few freshly gathered leaves to the sunshine in a glass vessel filled with water, and to collect the air-bubbles which presently arise while the light falls upon them, but which cease to appear when placed in shadow. This air, when examined, proves to be free oxygen gas. In nature, diffused daylight produces this effect; but in our experiments, direct sunshine is generally necessary to show it. What is the source of this oxygen gas, which is given up to the air just in proportion to the vigor of assimilation in the leafy plant, or, in other words, to the consumption of crude sap?

347. This will be manifest on comparing the materials with the general products of vegetation,—what the plant takes as its food, with what it makes of it, in growth. Suppose the plant is assimilating its food immediately into its fabric, viz. into *Cellulose*, or the substance of which its tissue consists (27). This matter, when in a pure state, and free from incrusting materials, has a perfectly uniform composition in all plants. It is composed of carbon, hydrogen, and oxygen, the latter two existing in the same proportions as in water.* It may therefore be said to consist of carbon and the elements of water. These materials are necessarily furnished by the plant's food. The mineral food of the plant, from which its fabric is made (329), is carbonic acid and water. If this be decomposed in vegetation, and the carbonic acid give up its oxygen, carbon and the elements of water remain,—the very composition of *cellulose* or vegetable tissue. Doubtless, then, the oxygen which is rendered to the air in vegetation comes from the carbonic acid which the plant took from the air (328).

348. This view may be confirmed by direct experiment. We

imbibed by the roots had absorbed from the air (326), and which passes off unaltered from the leaves when this water is evaporated, or from nitrogen in the air which the rootlets directly absorb. In the course of vegetation, no more nitrogen is given out than what is thus taken in, and probably not so much. So that the exhalation of nitrogen may be left out of the general view of changes which are brought about in vegetation.

* Cellulose is chemically composed of 12 equivalents of Carbon, 10 of hydrogen, and 10 of Oxygen, viz. $C_{12}H_{10}O_{10}$.

have seen that many plants *must*, and all *may*, imbibe the whole or a part of their food directly from the air into their leaves (330). All leafy plants evidently obtain a part of their carbonic acid in this way. It is accordingly found, that when a current of carbonic acid is made slowly to traverse a glass globe containing a leafy plant exposed to full sunshine, some carbonic acid disappears, and an equal bulk of oxygen gas supplies its place. Now, since carbonic acid gas contains just its own bulk of oxygen, it is evident that what has thus been decomposed in the leaves has returned all its oxygen to the air. Plants take carbonic acid from the atmosphere, therefore (directly or indirectly); they retain its carbon; they give back its oxygen.*

349. But cellulose, being the final, insoluble product of vegetation appropriated as tissue, can hardly be directly formed in the first instance. The substances from which it must originate, and which actually abound in the elaborated sap, are *Dextrine* or *Vegetable Mucilage* (79, 83), *Sugar* (80), &c. The first of these is probably directly produced in assimilation. Its chemical composition is the same as that of pure cellulose: it consists, not only of the same three elements, but of the same elements in exactly the same proportion. Dextrine, vegetable mucilage, &c. are the primary, as yet unappropriated materials of vegetable tissue, or unsolidified cellulose, and their production from the crude sap is attended with the evolution of the oxygen which was contained in the carbonic acid of the plant's food, as already stated. Nor would the result in any respect be altered if *Starch* were directly produced. This substance is merely dextrine, which, instead of being immediately appropriated in growth, is condensed into solid grains, and in that compact and

* At least, the result is as if the oxygen exhaled were all thus detached from the carbon of the carbonic acid. Just this amount is liberated, and the facts obviously point to the carbonic acid as its real source. But, on the other hand, it appears unlikely that a substance which holds oxygen with such strong affinity as carbon should yield the whole of it under these circumstances: and water is certainly decomposed, with the evolution of oxygen, in the formation of a class of vegetable products soon to be mentioned; besides, Edwards and Colin have shown that water is directly decomposed during germination. Still, as no one supposes that the residue after the liberation of oxygen is carbon and water, but only the three elements in the proportions which would constitute them, it amounts to nearly the same thing whether we say that the oxygen of the carbonic acid, or an amount of oxygen equivalent to that of the carbonic acid, derived partly from it and partly from the water, is liberated in such cases.

temporarily insoluble form accumulated as the ready prepared materials of future growth (82). Notwithstanding the difference in their properties and chemical reactions, these and other general ternary products (79) are strictly *isomeric*; that is, they consist of the same elements, combined in the same proportions; and physiologically they are merely different states of one and the same thing. Dextrine is the most soluble state, and is probably that originally formed in assimilation in the foliage: starch, amyloid (83), &c. are temporarily solidified states; and cellulose is the ultimate and usually permanent insoluble condition. Accordingly, whenever the materials of growth are supplied from accumulations of nourishment, as especially from the seed in germination (123–125), from fleshy roots (145), rootstocks, tubers, &c. (188–194), the starch or its equivalent is dissolved in the sap, being spontaneously reconverted into dextrine and sugar, and attracted in a liquid state into the growing parts, where, transformed into cellulose, it becomes a portion of the permanent vegetable fabric.

350. If, however, we suppose *sugar* to be a direct product of the assimilation of carbonic acid and water, the amount of oxygen gas exhaled will be just the same as before. For this has the same elementary composition as dextrine, starch, and cellulose, with the addition of one or two equivalents of water according to the kind.* And when formed as a transformation of dextrine, then the latter has only to appropriate some water. In the origination of all these products, therefore, the same quantity of carbonic acid is consumed, and all its oxygen restored to the air.† It is more and more evident,

* The formula for cane-sugar is C_{12}, H_{22}, O_{11} ; for grape-sugar, C_{12}, H_{22}, O_{11} .

† Since all these *neutral ternary substances* are identical, or nearly so, in elementary composition, and since, with the same amount of carbon, derived from the decomposition of carbonic acid, the plant can form them all, it will no longer appear surprising that they should be so readily convertible into each other in the living plant, and even in the hands of the chemist. But the chemistry of organic nature exceeds the resources of science, and constantly produces transformations which the chemist in his laboratory is unable to effect. The latter can change starch into dextrine, and dextrine into sugar; but he cannot reverse the process, and convert sugar into dextrine, or dextrine into starch. In the plant, however, all these various transformations are continually taking place. Thus, the starch deposited in the seed of the Sugar-cane, Indian Corn, &c. is changed into sugar in germination; and the sugar which fills the tissue of the stem at the time of flowering is rapidly carried into the flowers, where a portion is transformed into starch and again deposited in the newly-formed seeds. And

therefore, that, by just so much as plants grow, they take carbonic acid from the air, they retain its carbon, and return its oxygen.

351. In the production of that modification of cellulose called *Lignine* (42), which abounds in wood (if this be really a simple product, and not a mixture), not only must a larger amount of carbonic acid be decomposed, but a small portion of water also, with the liberation of its oxygen. For the composition attributed to it shows that it contains less oxygen than would suffice to convert its hydrogen into water.*

352. The whole class of fatty substances, including the *Oils*, *Wax*, *Chlorophyll* (84, 88, 92), &c., contain, some of them no oxygen at all (such as caoutchouc and Pine-oil), and all of them less oxygen than is requisite to convert their hydrogen into water. In their direct formation, if this be supposed, not only all the oxygen of the carbonic acid has been given out, but also a portion belonging to the water. If formed by a further deoxidation of neutral ternary products, the same result is attained as respects the liberation of oxygen gas, but by two or more steps instead of one. The *Resins*, doubtless, are not direct vegetable products, but originate from the alternation and partial oxidation of the essential oils. *Balsams*, which exude from the bark of certain plants, are natural solutions of resins in their essential oils, as rosin, or Pine-resin, in the oil of turpentine.

353. An opposite class, the *Vegetable Acids* (86), contain more oxygen than is necessary for the conversion of their hydrogen into water, but less than the amount which exists in carbonic acid and water. Indeed, the most general vegetable acid, the *oxalic* (which may be formed artificially by the action of nitric acid on starch), has no hydrogen, except in the atom of water that is connected with it. Acids are sometimes formed in the leaves, as in the Sorrel, the

although the chemist is unable to transform starch, sugar, &c. into cellulose, yet he readily effects the opposite change, by reconvertng woody fibre, &c. (under the influence of sulphuric acid) into dextrine and sugar. The plant does the same thing in the ripening of fruits, during which a portion of tissue is often transformed into sugar. Starch-grains and cellulose can never be formed artificially, because they are not merely organizable matter, but have an organic structure.

* According to Payen, lignine, separated as much as possible from cellulose, consists of Carbon 53.8, Hydrogen 6.0, and Oxygen 40.2 per cent, = $C_{25}H_{10}O_{20}$.

Grape-vine, &c., but usually in the fruit. If produced directly from the sap, as they may be in acid leaves, only a part of the oxygen in the carbonic acid which contributes to their formation would be exhaled. But if formed from sugar, or any other of the general products of the proper juice, the absorption of a portion of oxygen from the air would be required for the conversion; and this absorption takes place (at least in some cases) when fruits acquire their acidity. Even their formation by the plant, therefore, is attended by the liberation of oxygen gas, though in less quantity than in ordinary vegetation.

354. There is still another class of vegetable products of universal occurrence, and, although comparatively small in quantity in plants, yet of as high importance as those which constitute their permanent fabric; namely, the *neutral quaternary organic compounds*, of which nitrogen is a constituent (79). These, also, are mutually convertible bodies, related to each other as dextrine and sugar are to starch and cellulose, and playing the same part in the animal economy that the neutral ternary products do in the vegetable, i. e. forming the fabric of animals. The basis or type of these azotized products has received the name of *Proteine* (27): hence they are sometimes collectively called *proteine compounds*. In their production from the plant's food, the ammonia, or other azotized matter it contains, plays an essential part; and oxygen gas is restored to the air from the decomposition of all the carbonic acid concerned and of a part of the water.*

355. In living cells the *proteine* forms the *protoplasm*, or vitally active lining, which may be said to give origin to the vegetable structure, since the cellulose is deposited under its influence to form the permanent walls or fabric of the cells, as has already been explained (26-36). When the cells have completed their growth

* The chemical changes have been tabulated thus:—

The materials:					From which are formed the product:				
	C.	H.	N.	O.		C.	H.	N.	O.
74 of Water,		74		74	1 of Proteine,	48	36	6	14
94 of Carbonic acid, 94				188	4 of Cellulose,	48	40		40
2 of Carbonate of ammonia,		2	2	6	212 of Oxygen liberated,				212
		96	76	6			96	76	6
				266					266

Besides, *proteine* either contains or is naturally combined with a small quantity of *sulphur* and *phosphorus* (10).

and transformation, the protoplasm abandons them, the portion which is not decomposed being constantly attracted onwards into forming and growing parts, where it incites new development. For this azotized matter has the remarkable peculiarity of inducing chemical changes in other organic products, especially the neutral ternary bodies, causing one kind to be transformed into another, or even the decomposition of a part into alcohol, acetic acid, and finally into carbonic acid and water (as in germination, &c.),—itself remaining the while essentially unaltered.

356. The constant attraction of the protoplasm from the completed into the forming parts of the plants explains how it is, that so small a percentage of azotized matter should be capable of playing such an all-important part in the vegetable economy. It does its work with little loss of material, and no portion of it is fixed in the tissues. At least, the little that remains in old parts is capable of being washed out, showing that it forms no integral part of the fabric. This explains why the heartwood of trees yields barely a trace of nitrogen, while the sap-wood yields an appreciable amount, and the cambium-layer and all parts of recent formation, such as the buds, young shoots, and rootlets, always contain a notable proportion of it. This gives the reason, also, why sap-wood is so liable to decay (induced by the proteine), the more so in proportion to its newness and the quantity of sap it contains, while the completed heart-wood is so durable. The azotized matter rapidly diminishes in the stem and herbage during flowering, while it accumulates in the forming fruit, and is finally condensed in the seeds (which have a larger percentage than any other organ), ready to subserve the same office in the development of the embryo plant it contains.*

357. When wheat-flour, kneaded into dough, is subjected to the prolonged action of water, the starch is washed away, and a tenacious, elastic residue, the *Gluten* of the flour, which gives it the capability of being raised, remains. This contains nearly all the proteine compounds of the seed, mixed with some fatty matters (which may be removed by alcohol and ether) and with a little cellulose. The azotized products constitute from eight to thirty per cent of the weight of wheat-flour: the proportion varies greatly

* The cotyledons of peas and beans, according to Mr. Rigg, contain from 100 to 140 parts, and the plumule about 200 parts, of nitrogen, to 1,000 parts of carbon.

under different circumstances, but it is always largest when the soil is well supplied with manures that abound in nitrogen. The gluten of wheat is a mixture of four isomeric quaternary products, distinguished by chemists under the names *Fibrine* (identical in nature with that which forms the muscles of animals), *Albumen* (of the same nature as animal albumen), *Caseine* (identical with the curd of milk), and *Glutine*. In beans and all kinds of pulse, or seeds of Leguminous plants, the azotized matter principally occurs in the form of *Legumine*, which is nearly intermediate in character between albumen and caseine.

358. Comparing now these principal products of assimilation in plants with the inorganic materials from which they must needs be formed, it may clearly be perceived that the principal result of vegetation, as concerns the atmosphere, from which plants draw their food, consists in the withdrawal of water, of a little ammonia, and of a large proportion of carbonic acid, and of the restoration of oxygen. The latter is a constant effect of vegetation and the measure of its amount. As respects the fabric of the plant, the sole consequences of its formation upon the air are the withdrawal of a small quantity of water, and of a large amount of carbonic acid gas, and the restoration of the oxygen of the latter. In the formation of its azotized materials, a portion of ammonia or of some equivalent compound of nitrogen is also withdrawn. It is true, indeed, that leaves decompose carbonic acid only in daylight; and that they sometimes give a quantity of carbonic acid to the air in the night, especially when vegetation languishes, or even take from it a little oxygen. But this does not affect the general result, nor require any qualification of the general statement. The work simply ceases when light is withdrawn. The plant is then merely in a passive state. Yet, whenever exhalation from the leaves slowly continues in darkness, the carbonic acid which the water holds necessarily flies off with it, during the interruption to vegetation, into the atmosphere from which the plant took it. So much of the crude sap, or raw material, merely runs to waste. Furthermore, it must be remembered that the decomposition of carbonic acid in vegetation is in direct opposition to ordinary chemical affinity; or, in other words, that all organized matter is in a state corresponding to that of unstable equilibrium. Consequently, when light is withdrawn, ordinary chemical forces may perhaps to some extent resume their sway, the oxygen of the air combine with some of the newly deposited carbon

to reproduce a little carbonic acid, and thus demolish a portion of the rising vegetable structure which the setting sun left, as it were, in an unfinished or unstable state. This is what actually takes place in a dead plant at all times, and whenever an herb is kept in prolonged darkness; chemical forces, exerting their power uncontrolled, demolish the whole vegetable fabric, beginning with the chlorophyll (as we observe in blanching Celery), and at length resolve it into the carbonic acid and water from which it was formed. But this must all be placed to the account of *decomposing*, not of *growing* vegetation; and even if it were a universal phenomenon, which is by no means the case,* would not affect the general statement, that, *by so much as plants grow*, they decompose carbonic acid and give its oxygen to the air; or, in other words, purify the air.

359. Every six pounds of carbon in existing plants have withdrawn twenty-two pounds of carbonic acid gas from the atmosphere, and replaced it with sixteen pounds of oxygen gas, occupying the same bulk. To form some general conception of the extent of the influence of vegetation upon the air we breathe, therefore, we should compute the quantity of carbon, or charcoal, that is contained in the

* It is stated that many ordinary plants, when in full health and vigorous vegetation, impart no carbonic acid to the air during the night. — See Pepys, in *Philosophical Transactions*, for 1843. — Plants deteriorate the air only in their decay, and in peculiar processes, distinct from vegetation and directly the reverse of assimilation; as in germination, for instance, where the proteine induces the decomposition of a portion of the store of assimilated matter, in order that the rest may be brought into a serviceable condition. The evolution of carbonic acid by plants, therefore, when it occurs, is no part of vegetation. And it is by a false analogy that this loss which plants sustain in the night has been dignified with the name of *vegetable respiration*, and vegetables said to vitiate the atmosphere, just like animals, by their respiration, while they purify it by their digestion. If, indeed, this were a constant function, in any way contributing to maintain the life and health of the plant, it might be properly enough compared with the respiration of animals, which is itself a decomposing operation. But this is not the case. And herein is a characteristic difference between vegetables and animals: the tissues of the latter require constant interstitial renewal by nutrition, new particles replacing the old, which are removed and restored to the mineral world by *respiration*: while in plants there is no such renewal, but the fabric, once completed, remains unchanged, ceases to be nourished, and consequently soon loses its vitality; while new parts are continually formed farther on to take their places, to be in turn abandoned. Plants, therefore, having no decomposition and recomposition of any completed fabric, cannot properly be said to have the function of respiration.

forests and herbage of the world, and add to the estimate all that exists in the soil, as vegetable mould, peat, and in other forms; all that is locked up in the vast deposits of coal (the product of the vegetation of bygone ages); and, finally, all that pertains to the whole existent animal kingdom;—and we shall have the aggregate amount of a single, though the largest, element which vegetation has withdrawn from the atmosphere. By multiplying this vast amount of carbon by sixteen, and dividing it by six, we obtain an expression of the number of pounds of oxygen gas that have in this process been supplied to the atmosphere.

360. Rightly to understand the object and consequences of this immense operation, which has been going on ever since vegetation began, it should be noted, that, so far as we know, vegetation is the only operation in nature which gives to the air free oxygen gas, that indispensable requisite to animal life. There is no other provision for maintaining the supply. The prevailing chemical tendencies, on the contrary, take oxygen from the air. Few of the materials of the earth's crust are saturated with it; some of them still absorb a portion from the air in the changes they undergo; and none of them give it back in the free state in which they took it,—in a state to support animal life,—by any known natural process, at least upon any considerable scale. Animals all consume oxygen at every moment of their life, giving to the air carbonic acid in its room; and when dead, their bodies consume a further portion in decomposition. Decomposing vegetable matter produces the same result. Its carbon, taking oxygen from the air, is likewise restored in the form of carbonic acid. Combustion, as in burning our fuel, amounts to precisely the same thing; it is merely rapid decay. The carbon which the trees of the forest have been for centuries gathering from the air, their prostrate decaying trunks may almost as slowly restore to the air, in the original form of carbonic acid. But if set on fire, the same result may be accomplished in a day. All these causes conspire to rob the air of its life-sustaining oxygen. The original supply is indeed so vast, that, were there no natural compensation, centuries upon centuries would elapse before the amount of oxygen could be so much reduced, or that of carbonic acid increased, as to affect the existence of the present races of animals. But such a period would eventually arrive, were there no natural provision for the decomposition of the carbonic acid constantly poured into the air from these various

sources, and for the restoration of its oxygen. The needful compensation is found in the vegetable kingdom. While animals consume the oxygen of the air, and give back carbonic acid which is injurious to their life, this carbonic acid is the principal element of the food of vegetables, is consumed and decomposed by them, and its oxygen restored for the use of animals. Hence the perfect adaptation of the two great kingdoms of living beings to each other;—each removing from the atmosphere what would be noxious to the other;—each yielding to the atmosphere what is essential to the continued existence of the other.*

361. The relations of simple vegetation, under this aspect, to the mineral kingdom on the one hand, and the animal kingdom on the other, are simply set forth in the first part of the diagram placed at the close of this chapter.

362. But, besides this remotely essential office in purifying the air, the vegetable kingdom renders to the animal another service so immediate, that its failure for a single year would nearly depopulate the earth; namely, in providing the necessary food for the whole animal kingdom. It is under this view that the great office of vegetation in the general economy of the world is to be contemplated. Plants are the sole producers of nourishment. They alone transform mineral, chiefly atmospheric materials, they condense air, into organized matter. While they thus *produce* upon a vast scale, they *consume* or destroy comparatively little; and this never in proper vegetation, but in some special processes hereafter to be considered (370). Often when they appear to consume their own products, they only transform and transfer them, as when the starch of the potato is converted into new shoots and foliage.

363. Animals *consume* what vegetables produce. They themselves produce nothing directly from the mineral world. The herbivorous animals take from vegetables the organized matter which they have produced;—a part of it they consume, and in respiration restore the materials to the atmosphere, from which

* It is plain, however, that, while the animal kingdom is entirely dependent on the vegetable, the latter is independent of the former, and might have existed alone. The decaying races of plants, giving back their carbon to the air and to the soil by decay, would furnish food for their successors. And since all the carbonic acid which animals render to the air in respiration they have derived from their vegetable food, this would in time have found its way back to the air, for the use of new generations of plants, without the intervention of animals. At most, they merely expedite its return.

plants derived them, in the very form in which they were taken, namely, as carbonic acid and water. The portion they accumulate in their tissues constitutes the food of carnivorous animals; who consume and return to the air the greater part during life, and the remainder in decay after death. The atmosphere, therefore, out of which plants create nourishment, and to which animals as they consume return it, forms the necessary link between the animal and vegetable kingdoms, and completes the great cycle of organic existence. Organized matter passes through various stages in vegetables, through others in the herbivorous animals, and undergoes its final transformations in the carnivorous animals. Portions are consumed at every stage, and restored to the mineral kingdom, to which the whole, having accomplished its revolution, finally returns.

364. Moreover, plants not only furnish all the materials of the animal fabric, but furnish each principal constituent ready formed, so that the animal has only to appropriate it. The food of animals is of two kinds;—1. that which serves to support respiration and maintain the animal heat; 2. that which is capable of forming a portion of the animal fabric, of its flesh and bones. The ternary vegetable products furnish the first, in the form of sugar, vegetable jelly, starch, oil, &c., and even cellulose; substances which, containing no nitrogen, cannot form an integral part of the animal frame, but, conveyed into the blood, are decomposed in respiration; the carbon and the excess of hydrogen combining with the oxygen of the air, to which they are restored in the form of carbonic acid and water. Any portion not required by the immediate demands of respiration is stored in the tissues in the form of fat, (which the animal may either accumulate directly from the oily and waxy matters in its vegetable food, or produce by an alteration of the starch and sugar,) as a provision for future use: a deficiency of such materials subjects the tissues themselves, or the proper supporting food, to immediate decomposition in respiration. The quaternary or azotized products furnish the proper materials of the animal frame, the fibrine, caseine, albumen, &c. being directly appropriated from the vegetable food to form the blood, muscles, &c.; while a slight transformation of them gives origin to *gelatine*, of which the sinews, cartilages, and the organic part of the bones, consist. The earthy portion of the bones, the iron in the blood, and the saline ingredients of the animal body, are drawn from the earthy constituents (336) of the plants upon which the animal feeds. The animal merely ap-

appropriates and accumulates these already organizable materials, hanging them, it may be, little by little, as he destroys them, but rendering them all back (those of the first class through the lungs, of the second through the kidneys) finally to the earth and air, from which, and in the condition in which, the vegetable took them.

865. The general relations of vegetation to the mineral and animal kingdoms are exhibited in the subjoined diagram.

DIAGRAM ILLUSTRATING THE MUTUAL RELATIONS OF THE THREE KINGDOMS OF NATURE.

MINERAL KINGDOM.	VEGETABLE KINGDOM.	ANIMAL KINGDOM.	MINERAL KINGDOM.	
I. Vegetable Fabric.				
WATER { OXYGEN HYDROGEN CARBONIC ACID { CARBON OXYGEN	{ Cellulose, Starch, Sugar, fat, &c. OXYGEN HYDROGEN CARBON	{ Consumed by animals and in respiration, returned to the air, with the evolution of heat, as	OXYGEN { WATER. HYDROGEN CARBON { CARBONIC OXYGEN { ACID.	
II. Complete Vegetation.				
AMMONIA { HYDROGEN NITROGEN	{ Proteins and Cellulose OXYGEN CARBON	{ Albumen, Fibrine (Muscle), Gelatine (Skin), Caseine (Milk), &c. — returned as Urea, and finally resolved into Carbonate of Ammonia and Water,	HYDROGEN { AMMONIA. NITROGEN HYDROGEN { WATER. OXYGEN { CARBONIC CARBON { ACID.	
WATER { HYDROGEN OXYGEN				
CARBONIC ACID { CARBON OXYGEN				

CHAPTER VII.

OF FLOWERING AND ITS CONSEQUENCES.

366. PLANTS have thus far been considered only as respects their *Organs of Vegetation*,—those which essentially constitute the vegetable being, by which it grows, deriving its support from the surrounding air and soil, and converting these inorganic materials into its own organized substance. As every additional supply of nourishment furnishes materials for the development of new branches, roots, and leaves, thus multiplying both those organs which receive food and those which assimilate it, it would seem that, apart from accidents, the increase and extension of plants would be limited only by the failure of an adequate supply of nourishment. After a certain period, however, varying in different species, but nearly constant in each, a change ensues, which controls this otherwise indefinite extent of the branches. A portion of the buds, instead of elongating into branches, are developed in the form of FLOWERS; and nourishment which would otherwise contribute to the general increase of the plant, is devoted to their production, and to the maturation of the *fruit* and *seeds*.

367. *Flowering an Exhaustive Process.* Plants begin to bear flowers at a nearly determinate period for each species; which is dependent partly upon constitutional causes, and partly upon the requisite supply of nutritive matter in their system. For, since the flower and fruit draw largely upon the powers and nourishment of the plant, while they yield nothing in return, fructification is an exhaustive process, and a due accumulation of food is requisite to sustain it.*

* When the branch of a fruit-tree, which is sterile or does not perfect its blossoms, is *ringed* or *girdled* (by the removal of a narrow ring of bark), the elaborated juices, being arrested in their downward course, are accumulated in the branch, which is thus enabled to produce fruit abundantly; while the shoots that appear below the ring, being fed by the much weaker ascending sap, do not blossom, but push forth into leafy branches. So the flowers of most trees and shrubs that bear large or fleshy fruit are produced from lateral buds, resting directly upon the wood of the previous year, in which a quantity of nutritive matter is deposited. So, also, a seedling shoot, which would not flower for several years if left to itself, blossoms the next season when inserted as a graft into an older trunk, from whose accumulated stock it draws.

Annuals flower in a few weeks or months after they spring from the seed, when they have little nourishment stored up in their tissue ; and their lives are destroyed by the process (144) : biennials flower after a longer period, rapidly exhausting the nourishment accumulated in the root during the previous season, and then perishing (145) ; while shrubs and trees do not commence flowering until they are sufficiently established to endure it. The exhaustion consequent upon flowering, however, is often exhibited in fruit-trees, which, after producing an excessive crop (especially of late fruits, such as apples), sometimes fail to bear the succeeding year. When the crop of one year fails, the nourishment which it would have appropriated accumulates, and the tree may bear more abundantly the following season, and so on alternately from year to year.

368. The actual consumption of nourishment in flowering may be shown in a variety of ways ; as by the rapid disappearance of the farinaceous or saccharine store in the roots of the Carrot, Beet, &c. when they begin to flower, leaving them light, dry, and empty ; and by the rapid diminution of the sugar in the stalks of the Sugar-cane and of Maize at the same period. The stalks are therefore cut for making sugar just before the flowers expand, when they contain the greatest amount of saccharine matter.

369. The consequences of this exhaustion upon the duration of plants are further illustrated by the facility with which annuals may be changed into biennials, or their life prolonged indefinitely by preventing their flowering ; while they perish whenever they bear flowers and seed, whether during the first or any succeeding year. Thus, a common annual Larkspur has given rise to a double-flowered variety in the gardens, which bears no seed, and has therefore become a perennial. Cabbage-stumps, which are planted for seed, may be made to bear heads the second year by destroying the flower-shoots as they arise ; and the process may be continued from year to year, thus converting a biennial into a kind of perennial plant. The effect of flowering upon the longevity of the individual is strikingly shown by the Agave, or Century-plant, — so called because it flowers in our conservatories only after the lapse of a hundred, or at least a great number of years ; although, in its native sultry climate, it generally flowers when five or six years old. But whenever this occurs, the sweet juice with which it is filled at the time (which by fermentation forms *pulque*, the inebriating drink of the Mexicans) is consumed at a rate answering to the astonishing rapidity with which

its huge flower-stalk shoots forth (24), and the whole plant inevitably perishes when the seeds have ripened. So, also, the *Corypha*, or Talipot-tree, a magnificent Oriental Palm, which lives to a great age and attains an imposing altitude (bearing a crown of leaves, each blade of which is often thirty feet in circumference), flowers only once; but it then bears an enormous number of blossoms, succeeded by a crop of nuts sufficient to supply a large district with seed; and the tree perishes from the exhaustion.

370. Flowering and fruiting, then, draw largely upon the plant's resources, while they give back nothing in return. In these operations, as also in germination, vegetables act as true consumers (like animals, 363), decomposing their own products, and giving back carbonic acid and water to the air, instead of taking these materials from the air. It is in flowering that they actually consume most. In fruiting, although a large quantity of nourishment is taken from the plants, this is mostly accumulated in the fruit and seed, in a concentrated form, for the future use of the new individual in the seed.

371. The real consumption of nourishment by the flower is shown by the action of flowers upon the air, so different from that of leaves. While the foliage withdraws carbonic acid from the air, and restores oxygen (346, 358), flowers take a small portion of oxygen from the air, and give back carbonic acid. While leaves, therefore, purify the air we breathe, flowers contaminate it; though, of course, only to a degree which is relatively and absolutely insignificant. This process is necessarily attended by the

372. *Evolution of Heat.* When carbon is consumed as fuel, and by the oxygen of the air converted into carbonic acid, an amount of heat is evolved directly proportionate to the quantity of carbon consumed, or of carbonic acid produced. Precisely the same amount is more slowly generated during the gradual decomposition of the same quantity of vegetable matter by decay,—a heat which is employed by the gardener when he makes hot-beds of tan, decaying leaves, and manure,—or by the breathing of animals, which maintains their elevated temperature (364). The conversion of a given amount of carbon and hydrogen into carbonic acid and water, under whatever circumstances it may take place, and whether slowly or rapidly, generates in all cases the very same amount of heat. Now, since flowers consume carbon and produce carbonic acid, acting in this respect like animals, they ought to evolve heat in proportion to that consumption. This, in fact, they do. The evolution of heat

in blossoming was first observed by Lamarck, about seventy years ago, in the European Arum, which, just as the flowers open, "grows hot, as if it were about to burn." It was afterwards shown by Saussure in a number of flowers, such as those of the Bignonia, Gourd, and Tuberoe, and the heat was shown to be in direct proportion to the consumption of the oxygen of the air, or, in other words, of the carbon of the plant. The increase of temperature, in these cases, was measured by common instruments. But now that thermo-electric apparatus affords the means of measuring variations inappreciable by the most delicate thermometer, the heat generated by an ordinary cluster of blossoms may be detected. The phenomenon is most striking in the case of some large tropical plants of the Arum family, where an immense number of blossoms are crowded together and muffled by a hooded leaf, or spathe (390), which confines and reverberates the heat. In some of these, the temperature rises at times to twenty or even fifty degrees (Fahrenheit) above that of the surrounding air. This increase of temperature occurs daily, from the time the flowers open until they fade, but is most striking during the shedding of the pollen. At night, the temperature falls nearly to that of the surrounding air; but in the course of the morning the heat comes on, as it were like a *paroxysm of fever*, attaining the maximum, day after day, very nearly at the same hour of the afternoon, and gradually declining towards evening. In ordinary cases, the heat of flowering is more than counterbalanced by the vaporization of the sap and the absorption of solar heat by the foliage; so that the actual temperature of a leafy plant in summer is lower than that of the atmosphere.

373. We have remarked that the principal *consumption* takes place in the flower; and that a store is laid up in the fruit and seed. But much even of this store is consumed when the seed germinates; and in germination, as is seen in the malting of barley, a large amount of organic matter is decomposed into carbonic acid and water, and a proportionate quantity of heat is evolved. By a not very violent metaphor it may be said, therefore, that the fabled Phoenix is realized in the Century-plant (369), which, after living a hundred years, consumes itself in producing and giving life to its offspring, who literally rise from its ashes.

374. Plants need a Season of Rest. When plants are in luxuriant growth, rapidly pushing forth leafy branches, they are not apt to produce flower-buds. Our fruit-trees, in very moist seasons, or

when cultivated in too rich a soil, often grow luxuriantly, but do not blossom. The same thing is observed when our Northern fruit-trees are transported into tropical climates. On the other hand, whatever checks this continuous growth, without affecting the health of the individual, causes blossoms to appear earlier and more abundantly than they otherwise would. It is for this reason that transplanted fruit-trees incline to blossom the first season after their removal, though they may not do so again for several years. A state of comparative rest seems needful to the transformation by which flowers are formed. It is in autumn, or at least after the vigorous vegetation of the season is over, that our trees and shrubs, and most perennial herbs, form the flower-buds of the ensuing year.

375. The requisite annual season of repose, which in temperate climates is attained by the lowering of the temperature in autumn and winter, is scarcely less marked in many tropical countries, where winter is unknown. But the result is there brought about, not by cold, but by heat and dryness. The Cape of Good Hope, the Canary Islands, and the southern and interior parts of California, may be taken as illustrations. In the Canaries, the growing season is from November to March,—the winter of the northern hemisphere;—their winter also, as it is the coolest season, the mean temperature being 66° Fahr. But the rains fall regularly, and vegetation is active; while in summer, from April to October, it very seldom rains, and the mean temperature is as high as 73°. During this dry season, when the scorching sun reduces the soil nearly to the dryness and consistence of brick, ordinary vegetation almost completely disappears; and the Fig-Marigolds, Euphorbias, and other succulent plants, which, fitted to this condition of things, alone remain green, not unaptly represent the Firs and other ever-greens of high northern latitudes. The dry heat there brings about the same state of vegetable repose as cold with us. The roots and bulbs then lie dormant beneath the sunburnt crust, just as they do in our frozen soil. When the rainy season sets in, and the crust is softened by moisture, they are excited into growth under a diminished temperature, just as with us by heat; and the ready-formed flower-buds are suddenly developed, clothing at once the arid waste with a profusion of blossoms (194). The vegetation of such regions consists mainly of succulents, which are able to live through the drought and exposure; of bulbous plants, which run through their course before the drought becomes severe, then lose their

foliage, while the bud remains quiescent, safely protected under ground until the rainy season returns; and of annuals, which make their whole growth in a few weeks, and ripen their seeds, in which state the species securely passes the arid season.

376. These considerations elucidate the process of *forcing* plants, and other operations of horticulture, by which we are enabled to obtain in winter the flowers and fruits of summer. The gardener accomplishes these results principally by skilful alterations of the natural period of repose. He gives the plant an artificial period of rest by dryness at the season when he cannot command cold, and then, by the influence of heat, light, and moisture, which he can always command, causes it to grow at a season when it would have been quiescent. Thus he retards or advances, at will, the periods of flowering and of rest, or in time completely inverts them.

CHAPTER VIII.

OF THE INFLORESCENCE.

377. *Inflorescence* is the term used to designate the arrangement of flowers upon the stem or branch. The flower, like the branch, is evolved from a bud. Flower-buds and leaf-buds are often so similar in appearance, that it is difficult to distinguish one from the other before their expansion. The most conspicuous parts of the flower are so obviously analogous to the leaves of a branch, that they are called in common language the leaves of the flower. Such a flower as the double Camellia appears as if composed of a rosette of white or colored leaves, resembling, except in their color and texture, the clusters of leaves which are crowded on the offsets of such plants as the Houseleek (Fig. 207). We therefore naturally regard a flower-bud as analogous to a leaf-bud; and a flower, consequently, as analogous to a short leafy branch.

378. This analogy is confirmed by the position which flowers occupy. They appear at the same situations as ordinary buds, and at no other; that is, they occupy the extremity of the stem or branch, and the axil of the leaves (159, 165). Consequently, the arrange-

ment of the leaves governs the whole arrangement of the blossoms, as well as that of the branches. The almost endless variety of modes in which flowers are clustered upon the stem, many of them exhibiting the most graceful of natural forms, all implicitly follow the general law which has controlled the whole development of the vegetable from the beginning. We have, throughout, merely buds terminating the stem and branches, and buds from the axil of the leaves.

379. The simplest kind of inflorescence is, of course, that of a

solitary flower, — a single flower-stalk bearing a single flower; as in Fig. 306 and Fig. 327. The flower is solitary in both these instances; but in the latter case it occupies the summit of the stem, that is, it stands in the place of a terminal bud; in the former it arises from the axil of a leaf, or represents an axillary bud. These two cases exhibit, in their greatest simplicity, the two plans of inflorescence, to one or the other of which all flower-clusters belong.



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380. We begin with the second of these plans; in which the flowers all spring from axillary buds; while the terminal bud, developing as an ordinary branch, continues the stem or axis indefinitely. For the stem in such case may continue to elongate, and produce a flower in the axil of every leaf, until its powers are exhausted (Fig. 307). This gives rise, therefore, to what is called

381. **Indefinite or Indeterminate Inflorescence.** The primary axis is here never terminated by a flower; but the secondary axes (from axillary buds) are thus terminated. The various forms of indefinite inflorescence which in descriptive botany are distinguished by special names, as might be expected, run into one another through intermediate gradations. In nature they are not so absolutely fixed as in our written definitions; and whether this or that name should be used in a particular case is often a matter of fancy. The subjoined account of the principal kinds will at the same time bring to view the connection between them.

382. The principal kinds of indefinite inflorescence which have received distinctive names are the *Raceme*, the *Corymb*, the *Umbel*, the *Spike*, the *Head*, the *Spadix*, the *Catkin*, and the *Panicle*.

FIG. 306. A flowering branch of Moneywort, *Lysimachia nummularia*.

383. Before illustrating these, one or two terms, of common occurrence, may be defined. A flower which has no stalk to support it, but which sits directly on the stem or axis it proceeds from, is said to be *sessile*. If raised on a stalk, this is called its *PEDUNCLE*. If the whole flower-cluster is raised on a stalk, this keeps the name of peduncle, or *common peduncle* (Fig. 307, *p*); and the stalk of each particular flower, if it have any, takes the name of *PEDICEL* or *partial peduncle* (*p'*). The portion of the general stalk along which flowers are disposed is called the *axis of inflorescence*, or, when covered with sessile flowers, the *rhachis* (backbone), and sometimes (as when thick and covered with crowded flowers) the *receptacle*. The leaves of a flower-cluster generally are termed *BRACTS*. But when we wish particularly to distinguish their sorts, those on the peduncle, or main axis, and which have a flower in their axil, take the name of *Bracts* (Fig. 307, *b*); and those on the pedicels or partial flower-stalks, if any, that of *BRACTLETS* or *BRACTEOLES* (*b'*). The bracts are often reduced to a minute size, so as to escape ordinary notice: they very frequently fall off when the flower-bud in their axil expands, or even earlier; and sometimes, as in the greater part of the Mustard family, they altogether fail to appear.



384. A *Raceme* (Fig. 307, 308, 315) is that form of flower-cluster in which the flowers, each on their own footstalk or pedicel, are arranged along a common stalk or axis of inflorescence; as in the Lily of the Valley, Currant, Choke-Cherry, Barberry, &c. The lowest blossoms of a raceme are of course the oldest, and therefore open first, and the order of blossoming is *ascending*, from the bottom to the top. The summit, never being stopped by a terminal flower, may go on to grow, and often does so (as in the Snowberry, Shepherd's Purse, &c.), producing lateral flowers one after another throughout the season. In the raceme, the axis of inflorescence is more or less elongated, and the pedicels are about equal in length.

385. A *Corymb* (Fig. 309, 319) is the same as a raceme, except that the lower pedicels are elongated, so as to form a level-topped or slightly convex bunch of flowers; as in the Hawthorn, &c.

FIG. 307. A Raceme, with a general peduncle (*p*), pedicels (*p'*), bracts (*b*), and bractlets (*b'*).

386. An Umbel (Fig. 310) differs from a corymb only in having all the pedicels arising from the same apparent point, so as to resemble the rays of an umbrella;—the general peduncle, in this case, bearing several flowers without any perceptible elongation of the



axis of inflorescence. The Primrose and the Milkweed afford familiar examples of the simple umbel.

387. A corymb being evidently the same as a raceme with a short main axis, and an umbel the same as a corymb with a still shorter axis, it is evident that the outer flowers of an umbel or corymb correspond to the lowermost in the raceme, and that these will first expand, the blossoming proceeding regularly from the base to the apex, or (which is the same thing) from the circumference to the centre. This mode of development uniformly takes place when the flowers arise from axillary buds; on which account the indefinite mode of inflorescence is also called the *centripetal*.

388. In all the foregoing cases, the flowers are raised on stalks, or pedicels. When these are wanting, or so short as not to be apparent, a *Spike* or *Head* is produced.

389. A *Spike* is the same as the raceme, except that the flowers are sessile; as in the Plantain (Fig. 311) and Mullein. It is an in-

FIG. 308. A raceme. 309. A corymb. 310. An umbel.

FIG. 311. Young spike of *Plantago major*. 312. Catkin of White Birch.



determinate inflorescence, with the primary axis elongated, and the flowers destitute of pedicels or with only very short ones. Two varieties of the spike have received independent names, viz. the *Spadix* and the *Ament*.

390. A *Spadix* is a fleshy spike enveloped by a large bract or modified leaf, called a *SPATHE*, as in *Calla palustris* (Fig. 313), the Indian Turnip (Fig. 314), and the Skunk Cabbage (Fig. 1205).



391. An *Ament*, or *Catkin*, is merely that kind of spike with scaly bracts borne by the Birch (Fig. 312), Poplar, Willow, and, as to one of the two sorts of flowers, by the Oak, Walnut, and Hickory, which are accordingly called *amentaceous trees*. Catkins usually fall off in one piece, after flowering or fruiting, especially sterile catkins.

392. The *Head*, or *Capitulum*, is a globular cluster of sessile flowers, like that of Clover, the Button-Bush (Fig. 320), and the balls of the Buttonwood or Plane-tree. It is a many-flowered centripetal inflorescence, in which neither the primary axis nor the secondary axes are at all lengthened. We may view it either as an umbel without any pedicels, or as a spike with a very short axis. Generally it is of the latter character, as is evident in a Clover-head, where what was first a head frequently elongates into a spike as it grows older.

FIG. 313, 314. Spadix of *Calla* and of *Arum*, with the *spathe*. 315. A raceme of Cherry. 317. A cyme. 318. Panicle of Meadow-Grass. 319. A corymb.

393. The base both of the head and the umbel is frequently furnished with a number of imperfect leaves or bracts, crowded into a



cluster or whorl, termed an INVOLUCRE. The involucre assumes a great variety of forms; sometimes resembling a calyx; and sometimes



FIG. 320. Head of flowers of the Button-bush, *Cephalanthus occidentalis*.

FIG. 321. Plant of *Cornus Canadensis*, with its four-leaved involucre around a cluster of small flowers. 322. A separate flower enlarged.

FIG. 323. Flowering branch of Cichory, with two heads of ligulate flowers.

times (as in *Cornus Florida*, or the common Dogwood, and *C. Canadensis*, Fig. 321) becoming petal-like, and much more showy than the blossom itself. Here it is at once distinguished from the calyx or corolla by its including a number of flowers. Sometimes, however, as in the Mallow and Hibiscus, the involucre forms a kind of outer calyx to each flower.

394. The axis, or rhachis (382), of a head is called its **RECEPTACLE**. Frequently, instead of being globular or oblong, it is flat or depressed, and dilated horizontally, so as to allow a large number of flowers to stand on its level or merely convex surface; as in the Sunflower, Aster, Marigold, Dandelion, and Cichory (Fig. 323). Here, as in Fig. 321, a set of bracts form an involucre, surrounding the dense head of flowers. And as the involucre considerably resembles a calyx, while the outer flowers, often of a peculiar sort, are readily mistaken for petals, the head in these and similar plants was called a *compound flower* by the older botanists. Fig. 324 represents a section through a head of such flowers in a *Coreopsis*; and Fig. 325 is a slice of the same, more enlarged, displaying some of the separate flowers. In *Coreopsis*, as in the Sunflower, Yarrow, &c., each blossom of the head is subtended by its bract (*b*); and the bracts in such cases are called *Paleæ* or *Chaff*.



395. The FIG presents a case of very singular inflorescence

FIG. 324. Vertical section of a head of flowers of a *Coreopsis*.

FIG. 325. A slice of Fig. 324, more enlarged, with one tubular perfect flower (*a*) left standing on the receptacle, and subtended by its bract or chaff (*b*); also one ligulate and neutral ray-flower (*c*), and part of another: *d*, section of bracts or leaves of the involucre.

(Fig. 590 - 592), where the flowers apparently occupy the inside instead of the outside of the axis, being enclosed within the fleshy receptacle, which is hollow and nearly closed at the top. So that while a Sunflower, or the like, is an inflorescence imitating a blossom, a fig is an inflorescence imitating a fruit. Indeed, it is much like a mulberry (Fig. 593) or a pine-apple, turned inside out.

396. The foregoing are all forms of simple inflorescence; the ramification not passing beyond the first step; the lateral buds being at once terminated by a single flower. But the lateral flower-stalks may themselves branch, just as ordinary branches give rise to branchlets: then the inflorescence becomes compound. If the branches of a raceme are prolonged, and bear other flowers on pedicels similarly arranged, a *compound raceme* is produced; or if the flowers are sessile, a *compound spike* is formed. A corymb, the branches of which are similarly divided, forms a *compound corymb*; and an umbel, where the branches (often called *rays*) bear smaller umbels at their apex, is termed a *compound umbel*; as in the Caraway, Parsnip, and almost all the species of the family Umbelliferae, which is so named on this account.



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397. For these secondary umbels, a good English name has been employed by Dr. Darlington, that of **UMBELLETS**. Their involucre, when they have any, is distinguished from that of the principal umbel by the name of **INVOLUCEL**.

398. When the inflorescence is compound, it is readily seen that the different kinds of inflorescence may be combined; the first ramification following one plan, and the subdivision another. The combination is usually expressed by a descriptive phrase, as "spikes racemose, or racemed," "heads corymbose," &c. The combination of the raceme and the corymb or the cyme gives rise to a form of inflorescence which has a technical name, viz.:—

399. **The Panicle.** This is formed when the secondary axes of a raceme branch in a corymbose manner, as in most Grasses (Fig. 318, 326), or when those of a corymb divide in the manner of a raceme. And the name is applied to almost any open

FIG. 326. A panicle. (Compare with Fig. 307.)

and more or less elongated inflorescence which is irregularly branched twice, thrice, or a greater number of times.

400. A *Thyrus*, or *Thyrse*, is a compact panicle of a pyramidal, oval, or oblong outline; such as the cluster of flowers of the Lilac and Horsechestnut, a bunch of grapes, &c.

401. *Definite or Determinate Inflorescence.* In this class, the flowers all represent terminal buds (380). The primary axis is directly terminated by a single flower-bud, as in Fig. 327, and its growth is of course arrested. Here we have a solitary terminal flower. Further growth can take place only by the development of secondary axes from axillary buds. These may develop at once as peduncles, or as leafy branches; but they are in either case arrested, sooner or later, by a flower-bud, just as the primary axis was (Fig. 328). If further development ensues, it is by the production of branches of the third order, from the axils of leaves or bracts on the branches of the second order (Fig. 329); and so on. Hence this mode of inflorescence is said to be *definite* or *determinate*, in contradistinction to the indeterminate mode, already treated of, where the primary or leading axes elongate indefinitely, or merely cease to grow from the failure of nourishment, or some other extrinsic cause. The most common and most regular cases of determinate inflorescence occur in opposite-leaved plants, for obvious reasons; and such are accordingly chosen for the subjoined illustrations. But the Rose, Potentilla, and Buttercup furnish familiar examples of the kind in alternate-leaved plants.



402. The determinate mode of inflorescence assumes forms which may closely imitate those of the indeterminate kind, already described, and with which they have been confounded. When, for example, all the secondary axes connected with the inflorescence are arrested by terminal flowers, without any onward growth except

FIG. 327-329. Diagrams of regular forms of determinate or centrifugal inflorescence.

what forms their footstalks or pedicels, and these are nearly equal in length, a raceme-like inflorescence is produced, as in Fig. 330; or when the flowers have scarcely any pedicels, the spike is imitated.



These are distinguished from the true raceme and spike, however, by the reverse order of development of the blossoms; the terminal one opening earliest, and the others expanding in succession from above downwards; while the blossoming of the raceme proceeds from below upwards. Or when, by the elongation of the lower secondary axes, a corymb is imitated, the flowers are found to expand in succession from the centre of each ramification, beginning in the centre of the cluster, while the contrary occurs in the corymb. That is, while the order in indeterminate inflorescence is centripetal (387), that of the determinate mode is *centrifugal*. When the determinate inflorescence assumes the flattish or convex form, which it more commonly does, it has a distinctive name, viz. :—

403. **The Cyme.** This is a flat-topped, rounded or expanded inflorescence, whether simple or compound, of the determinate class; of which those of the Laurustinus, Elder, Dogwood, and Hydrangea (Fig. 420) are fully developed and characteristic examples. In compound and compact cymes, such as those of the Laurustinus, Dogwood, &c., the leaves or bracts are usually minute, rudimentary, or abortive, and all the numerous flower-buds of the cluster are fully formed before any of them expand; and the blossoming then runs through the whole cluster in a short time, commencing in the centre of the cyme, and then in the centre of each of its branches, and thence proceeding centrifugally. But in the Chickweeds (Fig. 331), in Hypericum, and many similar plants, the successive production of the branches and the evolution of the flowers, beginning with that which arrests the growth of the primary axis, go on gradually through the whole summer, until the powers of the plant are exhausted, or until all the branchlets or peduncles are reduced to single internodes, or pedicels destitute of leaves, bracts, or bractlets, when no further development can take place. Such cases enable us to study the determinate inflorescence to advantage, and to follow the successive steps of the ramification by direct observation.

404. A **Cymule** (*Cymula*) is a diminutive cyme, or a branch or cluster of a compound cyme.

FIG. 330. Definite inflorescence imitating a raceme.

405. The Fascicle is a very compact cyme, with upright or appressed branches ; as in the Sweet William.

406. A Glomerule is a cyme condensed into a kind of head. It is to the cyme what the head is to the corymb or umbel.



407. There are several abnormal modifications of definite inflorescence, arising from irregular development, or the suppression of parts, such as the non-appearance sometimes of the central flower, or often of one of the lateral branches at each division ; as in the ultimate ramifications of Fig. 331, where one of the lateral pedicels is wanting. When this deviation is completely manifested, that is, when one of the side branches regularly fails, the cyme is apparently converted into a kind of one-sided raceme, and the flowers seem to expand from below upwards, or centripetally. The diagram, Fig. 332, when compared with Fig. 331, explains this anomaly. The place of the axillary branch which fails to develop at each ramification is indicated by the dotted lines. Cases like this occur in several Hypericums, and in some other opposite-leaved plants. An analogous case occurs in many alternate-leaved plants ; where the stem, being terminated by a flower, is continued by a branch from the axil of the uppermost leaf or bract ; this, bearing a flower, is similarly prolonged by a secondary branch ; that by a third, and so on ; as is shown in the diagram, Fig. 333. Such forms of inflo-



FIG. 331. The open, progressively developed cyme of *Alsine Michauxii*.

FIG. 332, 333. Plan of two modifications of helicoid cymes or false racemes.

rescence, which we may observe in *Drosera*, *Sedum*, and *Houndstongue*, imitate the raceme so nearly, that they have commonly been considered as of that kind. They are distinguishable, however, by the position of the flowers *opposite* the leaf or bract, or at least out of its axil; while in the raceme, and in every modification of centripetal inflorescence, the flowers necessarily spring from the axils. But if the bracts disappear, as they commonly do in the *Forget-me-not*, &c., the true nature of the inflorescence is not readily made out. The undeveloped summit is usually *circinate*, or coiled in a spiral manner (Fig. 219), gradually unrolling as the flowers grow and expand, and becoming straight in fruit. On account of this coiled arrangement, such cymes or false racemes are said to be *helicoid*, or *scorpioid*.

408. The cyme, raceme, head, &c., as well as the one-flowered peduncle, may arise, either at the extremity of the stem or leafy branch (*terminal*), or in the axil of the leaves (*axillary*). The case of a peduncle opposite a leaf, as in the *Poke*, the *Grape-vine*, &c., is just that illustrated in Fig. 333, except that in these cases the peduncles bear a cluster of flowers instead of a single one. The tendrils of the *Vine* (Fig. 161) occupy the same position, and are of the same nature. In a growing *Grape-vine*, it is evident that the uppermost tendril really terminates the stem; and that the latter is continued by the growth of the axillary bud, situated between the petiole and the peduncle; the branch thus formed, assuming the direction of the main stem, and appearing to be its prolongation, throws the peduncle or tendril to the side opposite the leaf.

409. The *extra-axillary* peduncles of most species of *Solanum*, &c. are terminal peduncles, which have become lateral by the evolution of an axillary branch, with which the peduncle or the petiole is united for some distance. Such peduncles sometimes come from extra-axillary accessory buds (169).

410. In the *Linden* (Fig. 742) the peduncle appears to spring from the middle of a peculiar foliaceous bract. But this is rather a bractlet, inserted on the middle of the peduncle, and decurrent down to its base.

411. A peduncle which arises from the stem at or beneath the surface of the ground, as in *Bloodroot*, the *Primrose*, the so-called stemless *Violets*, &c., is called a *radical peduncle*, or a *SCAPE*.

412. A combination of the two classes of inflorescence is not unusual, the general axis developing in one way, but the separate

flower-clusters in the other. Thus the heads of the Sunflower and of all the so-called compound flowers (394) are *centripetal*, the flowers expanding regularly from the margin or circumference to the centre; while the branches that bear the heads are developed in the *centrifugal* mode, the central heads being earliest to come into blossom. This is exactly reversed in all *Labiatae* (plants of the Mint tribe); where the stem grows on indefinitely, producing axillary clusters in the form of a general raceme or spike, which blossoms from below upwards; while the flowers of each cluster form a cyme, and expand in the centrifugal manner. These cymes, or *cymules* (404), are usually close and compact, and being situated one in each axil of the opposite leaves, the two together frequently form a cluster which surrounds the stem, like a whorl or verticil (as in the Catnip and Horehound): hence such flowers are often said to be *whorled* or *verticillate*, which is not really the case, as they evidently all spring from the axils of the two leaves. The apparent verticil of this kind is sometimes termed a *VERTICILLASTER*.

413. True whorled flowers occur only in some plants with whorled leaves, as in *Hippuris* and the Water Milfoil.

CHAPTER IX.

OF THE FLOWER.

SECT. I. ITS ORGANS, OR COMPONENT PARTS.

414. HAVING glanced at the circumstances which attend and control the production of flowers, and considered the laws which govern their arrangement, we have next to inquire what the flower is composed of.

415. The Flower (117) assumes an endless variety of forms in different species, so that it is very difficult properly to define it. The name was earliest applied, as it is still in popular language generally applied, to the delicate and gayly colored leaves or petals, so different from the sober green of the foliage. But the petals, and all these bright hues, are entirely wanting in many flowers, while ordinary leaves sometimes assume the brilliant coloring of the

blossom The stamens and pistils are the characteristic organs of the flower; but sometimes one or the other of these disappear from a particular flower, and both are absent from full *double* Roses, Camellias, &c., in which we have only a regular rosette of delicate leaves. This, however, is an unnatural state, the consequence of protracted cultivation.



416. The flower consists of the organs of reproduction of a Phanogamous plant (114), and their envelopes. A *complete flower* consists of the essential organs of reproduction (viz. stamens and pistils), surrounded by two sets of leaves or envelopes which protect them. The latter are of course *exterior* or *lower* than the former, which in the bud they enclose.

417. The *Floral Envelopes*, then, are of two sorts, and occupy two circles, one above or within the other. Those of the lower circle, the exterior envelope in the flower-bud, form the *CALYX*: they commonly exhibit the green color and have much the appearance of ordinary leaves. Those of the inner circle, which are commonly of a more delicate texture and brighter color, and form the most showy part of the blossom, compose the *COROLLA*. The several parts or leaves of the corolla are called *PETALS*: and the leaves of the calyx take the corresponding name of *SEPALS*. One of the five sepals of the flower represented in Fig. 334 is separately shown in Fig. 336; and one of the petals in Fig. 337. The calyx and corolla, taken together, or the whole floral envelopes, whatever they may consist of, are sometimes called the *PERIANTH* (*Perianthium* or *Perigonium*).

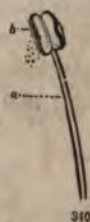


418. The *Essential Organs* of the flower are likewise of two kinds, and occupy two circles or rows, one within the other. The first of

FIG. 334. The complete flower of a *Crassula*. 335. Diagram of its cross-section in the bud, showing the relative position of its parts. The five pieces of the exterior circle are sections of the sepals; the next, of the petals; the third, of the stamens through their anthers; the innermost, of the five pistils.

FIG. 336. A sepal; 337, a petal; 338, a stamen; and 339, a pistil from the flower represented in Fig. 334.

these, those next within the petals, are the STAMENS (Fig. 338). A stamen consists of a column or stalk, called the FILAMENT (Fig. 340, *a*), and of a rounded body, or case, termed the ANTHER (*b*), filled with a powdery substance called POLLEN, which it discharges through one or more slits or openings. The older botanists had no general term for the stamens taken collectively, analogous to that of corolla for the entire whorl of petals, and of calyx for the whorl of sepals. A name has, however, recently been proposed for the *staminate system* of a flower, which it is occasionally convenient to use; that of ANDRÆCIUM.



419. The remaining, or seed-bearing organs, which occupy the centre or summit of the flower, to whose protection and perfection all the other parts of the flower are in some way subservient, are termed the PISTILS. To them collectively the name of GYNÆCIUM has been applied. One of them is separately shown in Fig. 339. This is seen more magnified and cut across in Fig. 342; and a different one, longitudinally divided, so as to exhibit the whole length of its cavity, or *cell*, is represented in Fig. 341.



420. A pistil is distinguished into three parts; namely, the OVARY (Fig. 341, *a*), the hollow portion at the base which contains the OVULES, or bodies destined to become seeds; the STYLE (*b*), or columnar prolongation of the apex of the ovary; and the STIGMA (*c*), a portion of the surface of the style denuded of epidermis, sometimes a mere point or a small knob at the apex of the style, but often forming a single or double line running down a part of its inner face, and assuming a great diversity of appearance in different plants.

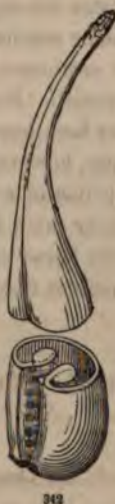
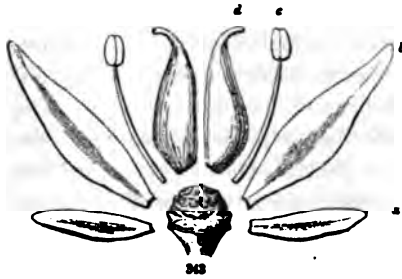


FIG. 340. A stamen, with the anther (*b*) discharging its pollen: *a*, the filament.

FIG. 341. Vertical section of a pistil, showing the interior of its ovary, *a*, to one side of which are attached numerous ovules, *d*: above is the style, *b*, tipped by the stigma, *c*.

FIG. 342. A Pistil of *Crassula*, like that of Fig. 339, but more magnified, and cut across through the ovary, to show its cell, and the ovules it contains. At the summit of the style is seen a somewhat papillose portion, destitute of epidermis, extending a little way down the inner face: this is the stigma.

421. All the organs of the flower are situated on, or grow out of, the apex of the flower-stalk, into which they are said, in botanical language, to be *inserted*, and which is called the **TORUS**, or **RECEPTACLE**. This is the axis of the flower, to which the floral organs are attached (just as leaves are to the stem); the calyx at its very base; the petals just within or above the calyx; the stamens just within the petals; and the pistils within or above the stamens (Fig. 343).



422. Such is the structure of a complete and regular flower; which we take as the *type*, or standard of comparison. The calyx and corolla are termed *protecting organs*. In the bud, they envelope the other parts: the calyx sometimes forms a covering even for

the fruit; and when it retains its leaf-like texture and color, it assimilates the sap of the plant with the evolution of oxygen gas, in the same manner as do true leaves: the corolla elaborates honey or other secretions, for the nourishment, as is supposed, of the stamens and pistils. Neither the calyx nor corolla is essential to a flower, one or both being not unfrequently wanting. The stamens and pistils are, however, *essential organs*, since both are necessary to the production of seed. But even these are not always both present in the very same flower; as will be seen when we come to notice the diverse forms which the blossom assumes, and to compare them with our pattern flower.

SECT. II. THE THEORETICAL STRUCTURE OR GENERAL MORPHOLOGY OF THE FLOWER.

423. To obtain at the outset a correct idea of the flower, it is needful here to consider the relation which its organs sustain to the organs of vegetation. Taking the blossom as a whole, we have recognized, in the chapter on Inflorescence (377), the identity of flower-buds and leaf-buds as to situation, &c. Flowers, consequently,

FIG. 343. Parts of the flower of a Stonecrop, *Sedum ternatum*, two of each sort, and the receptacle, displayed: a, sepal: b, petal: c, stamen: d, pistil.

are at least analogous to branches, and the leaves of the flower are analogous to ordinary leaves.

424. But the question which now arises is, whether the leaves of the stem and the leaves and the more peculiar organs of the flower are not *homologous* parts, that is, parts of the same fundamental nature, although developed in different shapes that they may subserve different offices in the vegetable economy; — just as the arm of man, the fore-leg of quadrupeds, the wing-like fore-leg of the bat, the true wing of birds, and even the pectoral fin of fishes, all represent one and the same organ, although developed under widely different forms and subservient to more or less different ends. The plant continues for a considerable time to produce buds which develop into branches. At length it produces buds which expand into blossoms. Is there an entirely new system introduced when flowers appear? Are the blossoms formed upon such a different plan, that the general laws of vegetation, which have sufficed for the interpretation of all the phenomena up to the inflorescence, are to afford no further clew? Or, on the contrary, now that peculiar results are to be attained, are the simple and plastic organs of vegetation — the stem and leaves — developed in new and peculiar forms for the accomplishment of these new ends? The latter, doubtless, is the correct view. The plant does not produce essentially new kinds of organs to fulfil the new conditions, but adopts and adapts the old. Notwithstanding these new conditions and the successively increasing difference in appearance, the fundamental laws of vegetation may be traced from the leafy branch into and through the flower. That is, the parts of the blossom are *homologous* with leaves, are leaves in other forms than that of foliage.

425. The student will have observed, that in vegetation no new organs are introduced to fulfil any particular condition, but the common elements, the root, stem, and leaves, are developed in peculiar and fitting forms to subserve each special purpose. Thus, the same organ which constitutes the stem of an herb, or the trunk of a tree, we recognize in the trailing vine, or the twiner, spirally climbing other stems, in the straw of Wheat and other Grasses, in the columnar trunk of the Palm, in the flattened and jointed Opuntia, or Prickly Pear, and in the rounded, lump-like body of the Melon-Cactus. So, also, branches harden into spines in the Thorn, or, by an opposite change, become flexible and attenuated tendrils in the Vine, and runners in the Strawberry; or, when developed under

ground, they assume the aspect of creeping roots, and sometimes form thickened monstrosities, as in the *Claytonia* and *Solomon's Seal*, or others, as in the *Pea*. But the type is readily seen through these disguises. They are all mere modifications of the stem. The leaves, as we have already seen, appear under a still greater variety of forms, some of them as widely different from the common type of foliage as can be imagined: such, for example, as the thickened and fleshy leaves of the *Mesembryanthemums*; the intense scarlet or crimson floral leaves of the *Euchroma*, or *Painted-Cup*, of the *Polkaetia* of our conservatories, and of several Mexican Sages; the tendrils of the *Pea* tribe; the pitchers of *Sarracenia* (Fig. 300), and also those of *Nepenthes* (Fig. 301), which are leaf, tendril, and pitcher combined. The leaves also appear under very different aspects in the same individual plant, according to the purposes they are intended to subserve. The first pair of leaves, or cotyledons, when gorged with nutritive matter for the supply of the earliest wants of the embryo plant, as in the *Almond*, *Bean*, *Pea*, &c. (Fig. 109-120), would seem to be peculiar organs. But in some of these cases, when they have discharged this special office in germination, by yielding to the young plant the store of nourishment with which they are laden, they imperfectly assume the color and appearance of foliage; while in other cases, as in the *Convolvulus* (Fig. 123) and the *Maple* (Fig. 164), they are green and foliaceous from the first. As the stem develops, the successive leaves vary in form or size, according to the varying vigor of vegetation. In our trees, we trace the last leaves of the season into bud-scales; and in the returning spring we may often trace the scales of opening buds through intermediate states back again into true leaves (161).

426. The analogies of vegetation would therefore lead us to expect, that in flowering the leaves would be wrought into new forms, to subserve peculiar purposes. In the chapter on Inflorescence, we have already learned that the arrangement and situation of flower upon the stem conform to this idea. In this respect, flowers are absolutely like branches. The aspect of the floral envelopes favors the same view. We plainly discern the leaf in the calyx, and again, more delicate and refined, in the petals. In numberless instances, we find a regular transition from ordinary leaves into sepals and from sepals into petals. And, while even the petals are occasionally green and herbaceous, the undoubted foliage sometimes assumes a delicate texture and the brightest hues (425). The

fect gradation of leaves or bracts into sepals is extremely common. The transition of sepals into petals is exemplified in almost every case where there are more than two rows of floral envelopes; as in the Magnolia, and especially in the White Water-Lily, various kinds of Cactus, the Illicium, or Star-Anise of the Southern States, and the Calycanthus, or Carolina Allspice, which present several series of floral envelopes, all nearly alike in color, texture, and shape; but how many of the innermost are to be called petals, and how the remainder are to be divided between sepals and bracts, is entirely a matter of arbitrary opinion. In fact, the only real difference between the calyx and corolla is, that the former is the outer, and the latter an inner series of floral envelopes. Sometimes the gradation extends one step farther, and exhibits an evident transition of petals into stamens; showing that these are of the same fundamental nature as the floral envelopes, which are manifestly traceable back to leaves. The White Water-Lily (Fig. 344) exhibits this latter transition, as evidently as it does that of sepals into petals. Here the petals occupy several whorls; and while the exterior are nearly undistinguishable from the calyx, the inner are reduced into organs which are neither well-formed petals nor stamens, but intermediate between the two. They are merely petals of a smaller size, with their summits contracted and transformed into imperfect anthers, containing a few grains of pollen: those of the series next within are more reduced in size, and bear perfect anthers at the apex; and a still further reduction of the lower part of the petal completes the transition into stamens of ordinary appearance.

427. By regular gradations, therefore, the leaf may be traced to



FIG. 344. A sepal, petals, bodies intermediate between petals and stamens, and true stamens, of the White Water-Lily.

the petal and the stamen. But we could not expect to meet with intermediate states between a stamen and a pistil, except as a monstrosity. The same organ could not fulfil such antagonistic offices. Nevertheless, stamens changing into pistils are occasionally found in monstrous blossoms. Cases of the kind are not very rare in Willows, where anthers are found either half changed or else perfectly transformed into pistils, and bearing ovules instead of pollen. In gardens some stamens of the common Poppy have been found changed into perfect pistils, and imperfect attempts of the kind are more frequently to be detected in the large Oriental Poppy. Two Apple-trees in Ashburnham, Massachusetts, have long been known, which annually produce flowers in which the petals are replaced by five small foliaceous bodies, resembling sepals, and in place of stamens there are ten separate and accessory pistils, inserted on the throat of the calyx.

428. This transformation of one organ into another is called *metamorphosis*. Assuming green foliage to be the natural state of leaves, the sepals and petals are said to be transformed or metamorphosed leaves; and the stamens and pistils are still more metamorphosed, losing as they ordinarily do all appearance of leaves. Still, if these organs be, as it were, leaves developed in peculiar states, under the controlling agency of a power which has overborne the ordinary forces of vegetation, they must always have a tendency to



develop in their primitive form, when the causes that govern the production of blossoms are interfered with during their formation. They may then reverse the spell, and revert into some organ below them in the series, as from stamens into petals, or pass at once into the state of ordinary leaves. That is, organs which from their position should be stamens or pistils may develop as petals or floral leaves, or else may revert at once to the state of ordinary leaves. Such cases of *retrograde metamorphosis* frequently occur in cultivated flowers.

429. Thus we often meet with the actual reconversion of what

45. A small leaf in place of a pistil from the centre of a flower of the double Cherry, an intermediate between a leaf and a pistil, from a similar flower.
 46. Leaflet of a Bryophyllum, developing buds along its margins.

should be a pistil into a leaf in the double Garden Cherry, either completely (Fig. 345), or else incompletely, so that the resulting organ (as in Fig. 346) is something intermediate between the two. *The change of what should be stamens into petals* is of common occurrence in what are called *double* and *semi-double* flowers of the gardens; as in Roses, Camellias, Carnations, &c. When such flowers have many stamens, these disappear as the supernumerary petals increase in number; and the various bodies that may be often observed, intermediate between perfect stamens (if any remain) and the outer row of petals,—from imperfect petals, with a small lamina tapering into a slender stalk, to those which bear a small distorted lamina on one side and a half-formed anther on the other,—plainly reveal the nature of the transformation that has taken place. Carried a step farther, the pistils likewise disappear, to be replaced by a rosette of petals, as in fully double Buttercups.

430. In full double Buttercups we may often notice a tendency in the inner petals to turn green, that is, to retrograde still farther into foliaceous organs. And there is a monstrous state of the Strawberry blossom, well known in Europe, in which all the floral organs revert into green sepals, or imperfect leaves. Fig. 348 exhibits a similar retrograde metamorphosis in a flower of the White Clover, where the calyx, pistil, &c. are still recognizable, although partially transformed into leaves. And the ovary, which has opened down one side, bears on each edge a number of small and imperfect leaves; much as the ordinary leaves, or rather leaflets, of Bryophyllum are apt to develop rudimentary tufts of leaves, or leaf-buds, on their margins (Fig. 347), which may grow into little plantlets, by which the species is often propagated. This retrograde metamorphosis of



FIG. 348. A flower of the common White Clover reverting to a leafy branch; after Turpin.

a whole blossom into foliaceous parts has been termed *chlorosis*, from the green color thus assumed.

431. A somewhat different proof that the blossom is a sort of branch, and its parts leaves, is occasionally furnished by monstrous flowers in the production of a leafy branch from the centre of a flower, or of one flower out of the centre of another (as rose-buds out of roses). Here the receptacle or axis of the flower resumes the

ordinary vegetative growth, as in Fig. 349, 350. In wet and warm springs, some of the flower-buds of the Pear and Apple are occasionally forced into vegetation, so as completely to break up the flower and change it into an ordinary leafy branch. This proves that the recep-



tle of a flower is of the nature of the stem.

432. An analogous kind of monstrosity, viz. the development of buds — either into leafy branches or into blossoms (Fig. 351) — in the axils of petals, or even of stamens or pistils, furnishes additional evidence that these bodies are of the nature of



leaves; for, whatever bears a bud or branch in its axil must represent a leaf.

433. The irresistible conclusion from all such evidence is, that the flower is one of the forms — the ultimate form — under which branches appear; that the leaves of the stem, the leaves or petals of the flower, and even the stamens and pistils, are all forms of a common

FIG. 349. Retrograde metamorphosis of a flower of the *Fraxinella* of the gardens, from Lindley's Theory of Horticulture; an internode elongated just above the stamens, and bearing a whorl of green leaves.

FIG. 350. A monstrous pear, prolonged into a leafy branch; from Bonnet.

FIG. 351. A flower of False Bittersweet (*Celastrus scandens*), producing other flowers in the axils of the petals; from Turpin.

type, only differing in their special development. And it may be added, that in an early stage of development they all appear nearly alike. That which, under the ordinary laws of vegetation, would have developed as a leafy branch, here develops as a flower; its several organs appearing under forms, some of them slightly, and others extremely, different in aspect and in office from the foliage. But they all have a common nature and a common origin, or, in other words, are homologous parts (424).

434. Now, as we have no general name to comprehend all those organs which, as foliage, bud-scales, bracts, sepals, petals, stamens, &c., successively spring from the ascending axis or stem, having ascertained their essential identity, we naturally take some one of them as the type, and view the others as modifications or metamorphoses of it. The leaf is the form which earliest appears, and is the most general of all the organs of the vegetable; it is the form which is indispensable to normal vegetation, since in it, as we have seen, assimilation is effected, and all organic matter is produced; it is the form into which all the floral organs may sometimes be traced back by numerous gradations, and to which they are liable to revert when flowering is disturbed and the vegetative forces again prevail. Hence the leaf may be properly assumed as the type or pattern, to which all the others are to be referred. When, therefore, the floral organs are called *modified* or *metamorphosed leaves*, it is not to be supposed that a petal has ever actually been a green leaf, and has subsequently assumed a more delicate texture and hue, or that stamens and pistils have previously existed in the state of foliage; but only that what is fundamentally one and the same organ develops, in the progressive evolution of the plant, under each or any of these various forms. When the individual organ has developed, its destiny is fixed.

435. The theory of vegetable morphology may be expressed in other and more hypothetical or transcendental forms. We have preferred to enunciate it in the simplest and most general terms. But, under whatever particular formula expressed, its adoption has not only greatly simplified, but has thrown a flood of light over the whole of Structural Botany, and has consequently placed the whole logic of Systematic Botany upon a new and philosophical basis. Our restricted limits will not allow us to trace its historical development. Suffice it to say, that the idea of the essential identity of the floral organs and the leaves was distinctly propounded by Lin-

næus,* about the middle of the last century. It was newly taught by Caspar Frederic Wolff, about twenty years later, and again, after the lapse of nearly twenty years more, by the celebrated Goethe, who was entirely ignorant, as were his scientific contemporaries, of what Linnaeus and Wolff had written on the subject. Goethe's curious and really scientific treatise was as completely forgotten or overlooked as the significant hints of Linnaeus had been. In advance of the science of the day, and more or less encumbered with hypothetical speculations, none of these writings appear to have exerted any appreciable influence over the progress of the science, until it had reached a point, early in the present century, when the nearly simultaneous generalizations of several botanists, following different clews, were leading to the same conclusions. Ignorant of the writings of Goethe and Wolff, De Candolle was the first to develop, from an independent and original point of view, the idea of symmetry in the flower; that the plan, or type, of the blossom is regular and symmetrical, but that this symmetry is more or less interfered with, modified, or disguised by secondary influences, such as suppressions, alterations, or irregularities, giving rise to the greatest diversity of forms. The reason of the prevailing symmetrical arrangement of parts in the blossom has only recently been made apparent, in the investigation of phyllotaxis (236); from which it appears that the general arrangement of the leaves upon the stem is carried out in the flower.

SECT. III. THE SYMMETRY OF THE FLOWER.

436. A **Symmetrical Flower** is one which has an equal number of parts in each circle or whorl of organs; as, for example, in Fig. 334, where there are five sepals, five petals, five stamens, and five pistils. It is not less symmetrical, although less simple, when there are two or more circles of the same kind of organ; as in *Sedum* (Fig. 361), where there are two sets of stamens, five in each; in the *Barberry*, where there are two or more sets of sepals, two of petals, and two of stamens, three in each set, &c. A *complete flower*

* "*Principium florum et foliorum idem est. Principium gemmarum et foliorum idem est. Gemma constat foliorum rudimentis. Perianthium sit ex con-*
natis foliorum rudimentis," etc. *Philosophia Botanica*, p. 301.

(as already defined, 416) is one that possesses both sorts of floral envelopes, calyx and corolla, and both essential organs, viz. stamens and pistils.

437. The simplest possible complete and symmetrical flower would be one with the calyx of a single sepal, a corolla of a single petal, a single stamen, and a single pistil; as in the annexed diagram (Fig. 352), which represents the elements of a simple stem (Fig. 157), terminated by an equally simple flower. Each constituent of the blossom represents a phyton (163), with its stem part reduced to a minimum, and its leaf part developed in a peculiar way, according to the rank it sustains and the office it is to fulfil. That there are short internodes between consecutive organs in the flower is usually apparent on minute inspection of its axis, or receptacle; and some of them are conspicuously prolonged in certain cases. But they are commonly so short that the organs are brought into juxtaposition, just as in a leaf-bud, and the higher or later-formed parts are interior or enclosed by the lower.

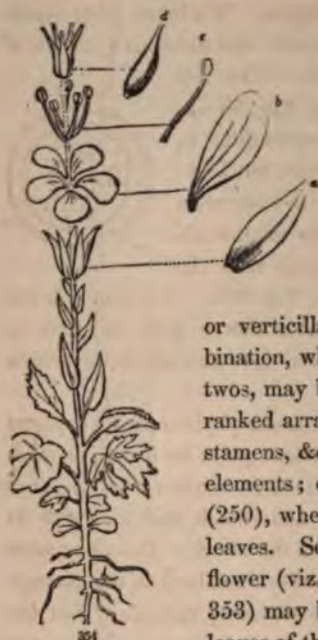
438. Perhaps the exact case of a flower at once so complete and so simple is not to be met with, the organs of the flower, or some of them, being generally multiplied. Thus we find a circle or whorl of each kind of organ, and often two or three circles, or a still larger and apparently indefinite number of parts. In fact, the floral organs usually occur in twos, threes, fours, or fives; and the same number is apt to prevail throughout the several circles of the flower, which therefore displays a symmetrical arrangement, or a manifest tendency towards it.*



* Terms expressive of the number of parts which compose each whorl of kind of organ — which are sometimes very convenient to use — are formed of

FIG. 352. Diagram of a plant, with a distichous arrangement of the phytons, carried through the complete flower, of the simplest kind, consisting of, *a*, a sepal; *b*, a petal; *c*, a stamen; and *d*, a pistil: *br* is the bract or uppermost proper leaf.

439. Having already noticed the symmetrical arrangement of the foliage (236-251), and remarked the transition of ordinary leaves



into those of the blossom (426), we naturally seek to bring the two under the same general laws, and look upon each floral whorl as answering either to a cycle of alternate leaves with their respective internodes undeveloped, or to a pair or verticil of opposite

or verticillate leaves. Thus, the simplest combination, where the organs are *dimerous*, or in twos, may be compared with the alternate two-ranked arrangement (238), the calyx, the corolla, stamens, &c. each consisting of one cycle of two elements; or else with the case of opposite leaves (250), when each set would answer to a pair of leaves. So, likewise, the organs of a *trimerous* flower (viz. one with its parts in threes, as in Fig. 353) may be taken either as cycles of alternate leaves of the tristichous mode (239), with the axis

shortened, which would throw the parts into successive whorls of threes, or else as proper verticils of three leaves; while those of a *pentamerous* or *quinary* flower (with the parts in fives, as in Fig. 354) would answer to the cycles of the $\frac{2}{5}$ arrangement (240) of alternate leaves, or to proper five-leaved verticils: So the whorls of a *tetramerous* flower are to be compared with the case of decussating op-

the Greek numerals combined with *mépos*, a part. Thus a flower with only one organ of each kind, as in the diagram, Fig. 352, is *monomerous*: a flower of a whorl of two organs is *dimerous* (Fig. 373); of three (as in Fig. 353), *trimerous*; of four, *tetramerous* (Fig. 405); of five (as in Fig. 354), *pentamerous*; of six, *hexamerous*; of ten, *decamerous*, &c. These words are often printed with figures, as 2-merous, 3-merous, 4-merous, 5-merous, and so on.

FIG. 353. Parts of a symmetrical trimerous flower (*Tillaea muscosa*): a, calyx; b, corolla; c, stamens; d, pistils.

FIG. 354. Ideal plan of a plant, with the simple stem terminated by a symmetrical pentamerous flower; the different sets of organs separated to some distance from each other, to show the relative situation of the parts; one of each, namely, a, a sepal, b, a petal, c, a stamen, d, a pistil, also shown, enlarged.

posite leaves, combined two by two, or with quaternary verticillate leaves (251); either of which would give sets of parts in fours.

440. *The Alternation of the Floral Organs.* We learn from observation that, as a general rule, the parts of the successive circles of the flower alternate with each other. The five petals of the flower represented in Fig. 334, for example, are not *opposed* to the five sepals (that is, situated directly above or before them), but *alternate* with them, that is, or stand over the intervals between them; the five stamens in like manner alternate with the petals, and the five pistils with the stamens, as is shown in the diagram, Fig. 335. The same is the case in Fig. 353, the several organs of a flower with its parts in threes; and in fact this is the rule, the few exceptions to which have to be separately accounted for.



441. This comports with the more usual phyllotaxis in opposite and verticillate leaves, where the successive pairs decussate, or cross each other at right angles (251), or the leaves of one verticil severally correspond to the intervals of that underneath, making twice as many vertical ranks as there are parts in the whorl. The alternation of the floral organs is therefore most readily explained on the assumption that the several circles are true decussating verticils. But the inspection of a flower-bud with the parts indicated in section (434) shows that the several members of the same set do not originate exactly in the same plane. The five petals, for example, in the cross-section of the pentamerous blossom shown in Fig. 335 (and the same arrangement is still more frequently seen in the calyx), are so situated, that two are exterior in the bud, and therefore inserted lower on the axis than the rest, the third is intermediate, and two others are entirely interior, or inserted higher than the rest. In fact, they exactly correspond with a cycle of alternate leaves of the quinquefolial or five-ranked arrangement, or an extremely abbreviated axis, or on a horizontal plane, as is at once seen by comparing the ground plan, Fig. 335, with Fig. 306. Compare also Fig. 335 with Fig. 333. Also, when the parts are in fives, two are almost always exterior in the bud, and two interior. Moreover, whenever the floral envelopes, or the stamens or pistils, are more numerous, or as to occupy several rows, the spiral disposition is the more manifest. It is most manifest, accordingly, in those cases that the calyx, corolla,

FIG. 335. Cross-section of the flower-bud of Fig. 333, to show the alternation of parts.

stamens, &c. of a pentamerous flower are each a depressed spiral or cycle of the $\frac{2}{5}$ mode of phyllotaxis, and those of the trimerous flower are similar spirals of the $\frac{1}{3}$ mode. But then the parts of the successive cycles should be superposed, or placed directly before each other on the depressed axis, as leaves are; whereas, on the contrary, they almost always alternate with each other in the flower.

442. To reconcile this alternation with the laws of phyllotaxis in alternate leaves, Prof. Adrien de Jussieu has advanced an ingenious hypothesis. He assumes the $\frac{1}{3}$ spiral arrangement as the basis of the floral structure both of the trimerous and pentamerous flower, (at least when the envelopes are imbricated in the bud,) this being the one that brings the successive parts most nearly into alternation, either in threes or in fives; as will readily be observed on inspection of the tabular projection of that mode, given on page 139. The difference between the position of parts in regular alternation, whether in threes or fives, and that assigned by an accurate spiral projection of the $\frac{1}{3}$ mode, is very slight as respects most of the organs, and in none does the deviation exceed one thirteenth of the circumference; — a quantity which becomes nearly insignificant on an axis so small as that of most flowers. Moreover, if the interior organs of a regular and symmetrical flower were thus to originate in the bud nearly in alternation with those that precede them, they would almost necessarily be crowded a little, as they develop, into the position of least pressure, and thus fall into these intervals with all the exactness that is actually found in nature. For in living bodies, endowed as they are with plasticity and a certain power of adaptation to circumstances, the positions assumed are not mathematically accurate; and the effect of unequal pressure in the bud in throwing the smaller parts more or less out of their normal position may be observed in almost any irregular flower. Moreover, in all the forms of phyllotaxis from $\frac{1}{3}$ onwards, it is doubtful whether what we term vertical ranks are exactly superposed. In tracing them upward to some extent, we perceive indications of a curviserial arrangement, where the superposition is continually approximated, but is never exactly attained (248). Lestibudois* has revived the older hypothesis of Jussieu, and others; viz. that a second spiral is introduced with the petals and continued in the pistils. And Schimper and Braun imagine a change of half the angular divergence (*prosenthesis*) to occur

* In *Annales des Sciences Naturelles*, ser. 4, Vol. 2, p. 226.

in passing from one cycle to the next; — which is rather describing the anomaly in other words than explaining it.

443. Whether we regard the floral circles as decussating verticils, or as cycles of alternate leaves in some way altered as to their succession, we cannot fail to discern an end attained by such arrangement, namely, a disposition of parts which secures the greatest economy of space on an abbreviated axis, and the greatest freedom from mutual pressure.

444. Position of the Flower as respects the Axis and subtending Bract. All axillary flowers are situated between a leaf and the stem, or, which is the same thing, between a bract and the axis of inflorescence. These two fixed points enable us to indicate the relative position of the parts of the floral circles with precision. That part of the flower which lies next the leaf or bract from whose axil it arises is said to be *anterior*, or *inferior* (lower): that which is diametrically opposite or next the axis is *posterior*, or *superior* (upper).*



It is important to notice the relative position of parts in this respect. This is shown in a proper diagram by drawing a section of the bract in its true position under the section of the flower-bud, as in Fig. 358: the position of the axis is necessarily diametrically opposite, and its section is sometimes indicated by a dot or small circle. In an axillary flower with the parts in fours, one of

* As if these were not terms enough, sometimes the organ, or side of the flower, which looks towards the bract, is likewise called *exterior*, and the organ or side next the axis, *interior*; but these terms should be kept to designate the relative position of the members of the floral circles in aestivation (494).

FIG. 356. Diagram of a Cruciferous flower (*Erysimum*); *a*, the axis of inflorescence. (The bract is abortive in this, as in most plants of this family.)

FIG. 357. Diagram of a flower of a *Rhus*, with the axis, *a*, and the bract, *b*, to show the relative position of parts.

FIG. 358. Diagram of a flower of the Pulse tribe: *a*, the axis, and *b*, the bract.

the sepals will be anterior, one posterior, and two lateral, or right and left; as in the annexed diagram of a Cruciferous blossom (Fig. 356); while the petals, alternating with the sepals, consist of an anterior and a posterior pair; and the stamens, again, stand before the sepals. An axillary flower of five parts will have either one sepal superior or posterior and two inferior or anterior (as in *Rhus*, Fig. 357), or else, *vice versâ*, one inferior and two superior, as in Papilionaceous flowers (Fig. 358): in both cases the two remaining sepals are *lateral*. The petals will consequently stand one superior, two inferior, and two lateral, in the last-named case; and one inferior, two superior, and two lateral, in the former. In terminal flowers (401), the position of parts in respect to the uppermost leaves or bracts should be noted.

SECT. IV. THE VARIOUS MODIFICATIONS OF THE FLOWER.

445. THE complete and symmetrical flowers, with all their organs in the most normal state, that have now been considered, will serve as the type or pattern, with which we may compare the almost numberless variety of forms which blossoms exhibit, and note the character of the differences observed. We proceed upon the supposition, that all flowers are formed upon a common plan, — a plan essentially the same as that of the stem or branch, of which the flower is a modified continuation, — so that in the flower we are to expect no organs other than those that, whatever their form and office, answer either to the axis or to the leaves; so that the differences between one flower and another are to be explained as circumstantial variations of one fundamental plan, — variations for the most part analogous to those which occur in the organs of vegetation themselves. Having assumed the *type* which represents our conception of the most complete, and at the same time the simplest flower, we apply it to all the cases which present themselves, and especially to those blossoms in which the structure and symmetry are masked or obscured; where, like the disenchanting spear of Ithuriel, its application at once reveals the real character of the most disguised and complicated forms of structure.

446. Our pattern flower consists of four circles, one of each kind floral organ, and of an equal number of parts, successively alternating with one another. It is *complete*, having both calyx and corolla.

as well as stamens and pistils (416); *symmetrical*, having an equal number of parts in the successive whorls (436); *regular*, in having the different members of each circle all alike in size and shape; it has but one circle of the same kind of organs; and, moreover, all the parts are distinct or unconnected, so as to exhibit their separate origin from the axis or receptacle of the flower. This type may be presented under either of the four numerical forms which have been illustrated. That is, its circles may consist of parts in twos (when it is *binary* or *dimerous*), threes (*ternary* or *trimerous*), fours (*quaternary* or *tetramerous*), or fives (*quinary* or *pentamerous*). The first of these is the least common; the trimerous and the pentamerous far the most so. The last is restricted to Dicotyledonous plants, where five is the prevailing number; while the trimerous flower largely prevails in Monocotyledonous plants, although by no means wanting in the Dicotyledonous class, from which Fig. 353 is taken.

447. The principal deviations from the perfectly normal or pattern flower may be classified as follows. They arise, either from, —

1st. The production of additional circles of one or more of the floral organs (*regular multiplication* or *augmentation*);

2d. The production of a pair or a cluster of organs where there should normally be but one, that is, the multiplication of an organ by division (*abnormal multiplication*, also termed *deduplication* or *chorisis*);

3d. The *anteposition* (or opposition, instead of alternation) of the parts of successive circles;

4th. The union of the members of the same circle (*coalescence*);

5th. The union of adjacent parts of different circles (*adnation*);

6th. The unequal growth or unequal union of different parts of the same circle (*irregularity*); or,

7th. The non-production or abortion of some parts of a circle, or of one or more complete circles (*suppression* or *abortion*).

8th. To which may be added, the abnormal development of the receptacle or axis of the flower.

448. Some of these deviations interfere with the symmetrical structure of the flower; others merely render it irregular, or disguise the real origin or the real number of parts. These deviations, moreover, are seldom single; but two, three, or more of the kinds frequently co-exist, so as to realize almost every conceivable variation.

449. Several of these kinds of deviation may often be observed

even in the same natural family of plants, where it cannot be doubt-
ed that the blossoms are constructed upon a common plan in all the
species. Even in the family Crassulaceae, for example, where the



flowers are remarkably symmetrical, and from which our pattern flowers, Fig. 334 and 353, are derived, a considerable number of these diversities are to be met with. In *Crassula*, we have the completely symmetrical and simple pentamerous flower (Fig. 359, 360), viz. with a calyx of five sepals, a corolla of five petals alternate with the former, an androecium (418) of five stamens alternating with the petals, and a gynæcium (419) of five pistils, which are alternate with the stamens; and all the parts are regular and symmetrical, and also distinct and free from each other; except that the sepals are somewhat united at the base, and the petals and stamens slightly connected with the inside of the calyx, instead of arising directly from the recep-

table or axis, just beneath the pistils. Five is the prevailing or normal number in this family. Nevertheless, in the related genus *Tillæa*, most of the species, like ours of the United States, have their parts in fours, but are otherwise similar, and one common European species has its parts in threes (Fig. 353); that is, one or two members are left out of each circle, which of course does not interfere with the symmetry of the blossom. So in the more conspicuous genus *Sedum* (the Stonecrop, Live-for-ever, Orpine, &c.), some species have their parts in fives; others in fours; and several, like our *S. ternatum*, have those of the first blossom in fives, but all the rest in fours. But *Sedum* also illustrates the case of regular augmentation (447, 1st) in its androecium, which consists of twice as many stamens as there are members in the other parts; that is, an additional circle of stamens is introduced (Fig. 361), the members which may be distinguished by being shorter or a little later t



FIG. 359. Flower of a *Crassula*. 360. Cross-section of the bud.

FIG. 361. Flower of a *Sedum* or Stonecrop.

those of the primary circle, and by their alternation with these, which brings them directly opposite the petals. A third genus (*Rochea*) exhibits the same pentamerous and normal flower as *Crassula*, except that the contiguous edges of the petals slightly cohere about half their length, although a little force suffices to separate them: in another (*Grammanthes*, Fig. 362), the petals are firmly united into a tube for more than half their length, and so are the sepals likewise; illustrating the fourth of the deviations above enumerated (447). Next, the allied genus *Cotyledon* (Fig. 363) exhibits in the same flower both this coalescence of similar parts, and an additional circle of stamens, as in *Sedum*. It likewise presents the next order of deviations, in the union (adnation) of the base of its stamens to the base of the corolla, out of which they apparently arise, as is seen in Fig. 364, where the corolla is laid open and displayed. The pistils, although ordinarily exhibiting a strong tendency to unite, are perfectly distinct in all these cases, and indeed throughout the order, with two exceptions; one of which is seen in *Penthorum*, where the five ovaries (Fig. 365) are united below into a solid body, while their summits, as well as the styles, are separate. The same plant also furnishes an example of the non-production (or *suppression*) of one set of organs, that of the petals; which, although said to exist in some specimens, are ordinarily wanting altogether. Another instance of increase in the number of parts occurs in the Houseleek (*Sempervivum*), in which the sepals, petals, and pistils vary in different species from six to twenty, and the stamens from twelve to forty.



450. Some illustrations of the principal diversities of the flower,

FIG. 362. Flower of *Grammanthes*. 363. Flower of a *Cotyledon*. 364. The corolla laid open, showing the two rows of stamens inserted into it. 365. The five pistils of *Penthorum* united. 366. A cross-section of the same.

as classified above (447), may be drawn at random from different families of plants; and most of the technical terms necessarily employed in describing these modifications may be introduced, and explained, as we proceed. The multiplication of parts is usually in consequence of the

451. **Augmentation of the Floral Circles.** An increased number of circles or parts of all the floral organs occurs in the Magnolia family; where the floral envelopes occupy three or four rows, of three leaves in each, to be divided between the calyx and corolla, while the stamens and pistils are very numerous, and compactly arranged on the elongated receptacle. The Custard-Apple family, which is much like the last, has also two circles in the corolla, three petals in each, a great increase in the number of stamens, and, in our Papaw (Fig. 654), sometimes only one circle of pistils, viz. three, sometimes twice, thrice, or as many as five times that number. The Water-Lily, likewise, has all its parts augmented, the floral envelopes and the stamens especially occupying a great number of rows; and the pistils are likewise numerous, although their number is disguised by being united into one body. When the sepals, petals, or other parts of the flower are too numerous to be readily counted, or even exceed twelve, especially when the number is inconstant, as it commonly is in such cases, they are said to be *indefinite*; and a flower with numerous stamens is also termed *polyandrous*.

452. When such multiplication of the floral circles is perfectly regular, the number of the organs so increased is a multiple of that which forms the basis of the flower; but this could scarcely be determined when the numbers are large, as in the stamens of a Buttercup, for example, nor is there much constancy when the whorls of any organ exceed three or four. The doubling or trebling of any or all the floral circles does not interfere with the symmetry of the flower; but it may obscure it (in the stamens and pistils especially), by the crowding of two or more circles of five members into what appears like one of ten, or two trimerous circles into what appears like one of six. The latter case occurs in most Eudogenous plants.

453. The production of additional floral circles may account for most cases of increase of the normal number of organs, but not for all of them. It must, we think, be admitted that certain parts of the blossom are sometimes increased in number by the production of a double organ, or a pair or a group of organs which occupy the place of one; namely, by what has been termed

454. **Chorisis or Deduplication.** The name *dédoublément* of Dunal, which has been translated *deduplication*, literally means *unlining*; the original hypothesis being, that the organs in question *unline*, or tend to separate into two or more layers, each having the same structure. We may employ the word *deduplication*, in the sense of the doubling or multiplication of the number of parts, without adopting this hypothesis as to the nature of the process, which at best can well apply only to some special cases. The word *chorisis* (*χώρασις*, the act or state of separation or multiplication), also proposed by Dunal, does not involve any such assumption, and is accordingly to be preferred. By regular multiplication, therefore, we mean the augmentation of the number of organs through the development of additional circles; which does not alter the symmetry of the flower. By chorisis we denote the production of two or more organs in the place of one, in a manner analogous to the division of the blade of a leaf into a number of separate blades, or leaflets.

455. Chorisis, or the division of an organ into a pair or a cluster, may take place in two ways. In one case the parts or organs thus produced stand one before the other; in the other case they stand side by side. The first is named *transverse chorisis*; the second, *collateral chorisis*. Both must evidently disturb or disguise the normal symmetry of the blossom.

456. **Collateral Chorisis** is that in respect to which there is least doubt as to the nature of the process. We have a good example of it in the *tetradynamous* stamens (519) of the Mustard or Cress family (Fig. 406). Here, in a flower with a symmetrical tetramerous calyx and corolla, we have six stamens; of which the two lateral or shorter ones are alternate with the adjacent petals, as they normally should be, while the four are in two pairs, one pair before each remaining interval of the petals; as is shown in the annexed diagram (Fig. 367). That is, on the anterior and on the posterior side of the flower we have two stamens where there normally should be but a single one, and where,



FIG. 367. Diagram of a (tetradynamous) flower of the order Cruciferae.

FIG. 368. Flower of *Streptanthus hyacinthoides*, from Texas (the sepals and stamens removed), showing a forked or double stamen in place of the anterior pair.

indeed, there is but one in a few plants of this family. Now it occasionally happens that the doubling of this stamen is, as it were,

arrested before completion, so that in place of two stamens we have a forked filament bearing a pair of anthers; as frequently happens in some species of *Streptanthus* (Fig. 368). Here the two stamens in place of one may be compared with a compound leaf of two leaflets. In the related *Fumitory* family three stamens regularly appear in the place of one. The circles of the flower are in twos throughout; viz. there is,

first, a pair of small scale-like sepals; alternate with these, a pair of petals, which, in *Dicentra*, &c. (Fig. 369–371), are saccate or spurred below; alternate and within these is a second pair of petals (Fig. 372); alternate with these are two clusters of three more or less united stamens, which plainly occupy the place of two single stamens. The arrangement of parts is shown in the annexed diagram (Fig. 373); where the lowest line indicates the subtending bract, and therefore the anterior side of the blossom; the two short lines in the same plane represent the sepals; the two

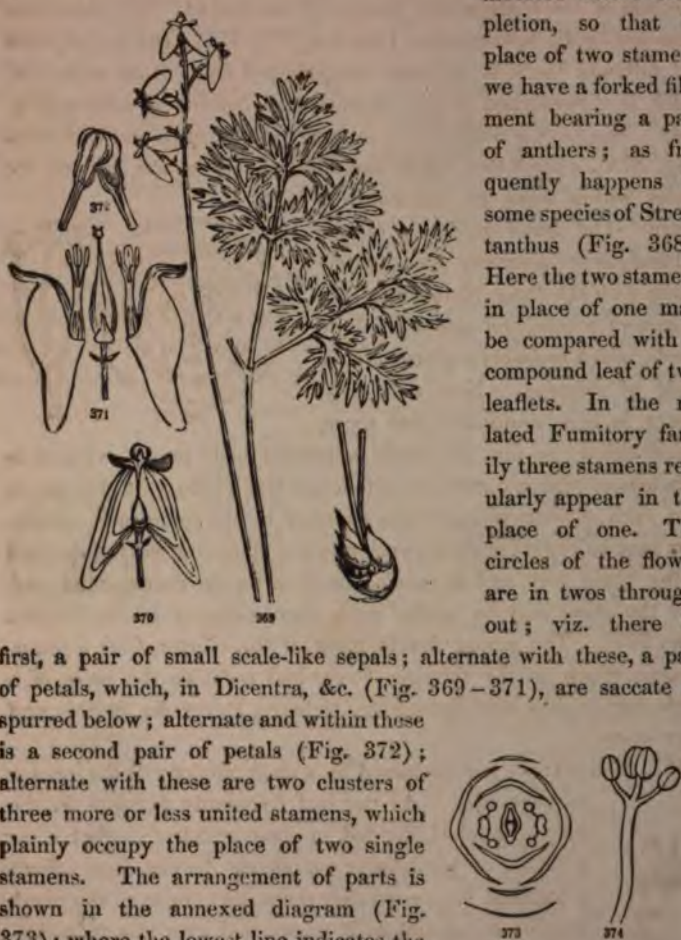


FIG. 369. *Dicentra Cucullaria* (Dutchman's-Breeches), with its kind of bulb, a leaf, and a scape in flower; reduced in size. 370. A flower of the natural size. 371. The same, with the parts separated, except the sepals, one of which is seen at the base of the pistil. 372. The inner pair of petals, with their tips coherent.

FIG. 373. Diagram (cross-section) of the similar flower of *Adonis*. 374. One of the stamens increased into three by chorisis (the lower part of the common filament is cut away).

next within, the lateral and exterior petals; those alternate and within these, the inner circle of petals; and alternate with these are the anthers of the two stamen-clusters. The centre is occupied by a section of the pistil, which consists of two united. The three stamens are lightly connected in *Dicentra* (Fig. 371); but in *Corydalis* and *Adlumia* there is only one strap-shaped filament on each side, which is three-forked at the tip, each fork bearing an anther. (Fig. 374). We have a similar case in some *Hypericums* and in *Elodea* (Fig. 375), except that, while the floral envelopes are in fives, the circles within them are commonly in threes. The three members of the andrœcium are normally placed, alternating with the three members of the gynœcium within, and also with three glands, which probably replace another circle of stamens. Now each real stamen is here multiplied into three, united below; so that the whole compound body may be viewed as homologous with a compound trifoliate leaf (289). If this be so, then each cluster of numerous stamens in the common *St. Johnswort* may be regarded as answering to one stamen greatly multiplied in the same way, and as analogous to a sessile decompound leaf. And the same may be said of each stamen-cluster in the *Linden* (Fig. 383). The actual development of the cluster, from a protuberance which in the forming flower-bud occupies the place of a single stamen, has been traced by Duchatre, Payer, &c. in this and other cases.



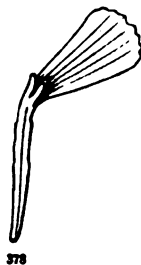
457. Thus far we are sustained by a clear analogy in the organs of vegetation. As the leaf frequently develops in the form of a lobed, divided, or compound leaf,—that is, as a cluster of partially or completely distinct organs from a common base,—so may the stamen, or even the pistil, become compound as it grows, and give rise to a cluster, instead of completing its growth as a solitary organ: and it appears that the organogeny is strikingly similar in the two cases. Nor is it very unusual for petals to become divided or deeply lobed in the same manner; as, for example, those

FIG. 375. Diagram (cross-section) of a flower of *Elodea Virginica*. 376. One of the three stamen-clusters, consisting of a trebled stamen, enlarged.

FIG. 377. A petal of *Mignionette*, enlarged.

of Mignonette (Fig. 377). In certain cases an analogous division takes place in the opposite direction, so that the parts or lobes are situated one before the other. An indication of this is also manifest in the petals of Mignonette, the lower part or broad claw of which is slightly extended at its summit, on each side, beyond the origin of the many-cleft limb or blade. Division in this direction has been termed

458. **Transverse or Vertical Chorisis.** The most familiar case is that of the *crown*, or small and mostly two-lobed appendage on the inside of the blade of the petals of *Silene* (Fig. 378) and of many other Caryophyllaceous plants. This is more like a case of real *dédoublement* or *unlining*, i. e. a partial separation of an inner lamella from the outer, and perhaps may be so viewed. Stamens sometimes bear a similar and more striking appendage, as in *Larrea*, for example (Fig. 379), and most other plants of the *Guaiacum* family; also in the



Dodder (Fig. 1044). Let it be noted that in all such cases the appendage occupies the inner side of the petal or stamen, and that it is commonly two-lobed. Again, before each petal of *Parnassia* (Fig. 381), although slightly if at all united with it, is found a body which in *P. palustris* is somewhat petal-like, with a considerable number of lobes, and in *P. Caroliniana* is divided almost to the base into three lobes, which look much like abortive

stamens. The true staminal circle, however, occupies its proper place within these ambiguous bodies, alternate with the petals. We cannot doubt that the former are of the same nature as the scale of the stamens in *Larrea*, and the crown of the petals



FIG. 378. A petal of *Silene Pennsylvanica*, with its *crown* or appendage.

FIG. 379. A stamen of *Larrea Mexicana*, with a scale-like appendage cohering with its base on the inner side.

FIG. 380. Diagram (cross-section) of the flower of *Parnassia Caroliniana*. 381. A petal, with the appendage that stands before it.

of *Silene*; and we incline to consider the accessory body in such cases as homologous with the stipules of the leaf.*

459. It may also be noticed, that, while in collateral chorisis the increased parts are usually all of the same nature, like so many similar leaflets of a compound leaf, in what is called transverse chorisis there is seldom such a division into homogeneous parts; but the original organ remains, as it were, intact, while it bears an appendage of some different appearance or function on its inner face, or at its base on that side. Thus the stamens of *Larrea*, &c. bear

* For fuller illustrations of these theoretical points, the student is referred to the figures and text of *The Genera of the United States Flora Illustrated*, especially to Vol. 2. — An able writer in Hooker's *Journal of Botany and Kew Garden Miscellany*, Vol. 1, p. 360, (with whom we are in accord as to the nature of collateral chorisis,) "being totally at a loss to find anything analogous in the ordinary stem-leaves" to this transverse or vertical multiplication of parts, inclines to consider such appendages as those of the petals of *Silene*, *Sapindus*, *Ranunculus*, &c. as deformed glands, and the stamens thus situated, whether singly or in clusters, as developments of new parts in the axil of the petals, &c. It appears to us, however, that the leaves do furnish the proper analogue of such appendages as those of Fig. 378-381, and the similar petaloid scales of *Sapindaceæ*, *Erythroxyleæ*, and the like, in the *ligule* of Grasses, and the stipules. The former occupies exactly the same position. The latter form an essential part of the leaf, and usually develop in a plane parallel with that of the blade, but between it and the axis; particularly when they are of considerable size, and serve as teguments of the bud, as, for example, in *Magnolia* (Fig. 156). The combined intrapetiolar stipules of *Melianthus* furnish a case in point, to be compared with the two-lobed internal scale of the stamens in *Larrea*, the two-cleft adnate appendage of the petals in *Caryophyllææ*, *Sapindus*, &c.; and instances of cleft or appendaged stipules may readily be adduced to show that such bodies are as prone to multiplication by division as other foliar parts. The supposition of a true axillary origin of the organs in question, therefore, appears to be gratuitous, and it would certainly introduce needless complexity into the theory of the flower. Nor does it throw any light upon their morphology to call such appendages of petals "deformed glands"; a term which is much too vague to have any assignable morphological value. In *Linum* true stipules are reduced to glands. At present, therefore, we think that the same general name may properly enough be employed both for the collateral and the vertical multiplication of organs, where two or more bodies occupy the place of one, carefully distinguishing, however, the two different cases. Some special term is needful for discriminating between such multiplication and that by the regular augmentation of floral organs through the development of additional circles, and none the less so, because we recognize, in one or both kinds of *chorisis*, modes of division which are common to the floral organs and to the foliage.

a scale-like appendage: the petals of *Sapindus*, *Cardiospermum*, &c., a petaloid scale quite unlike the original petal; the petals of *Parmanthus*, a cluster of bodies resembling sterile filaments united below.

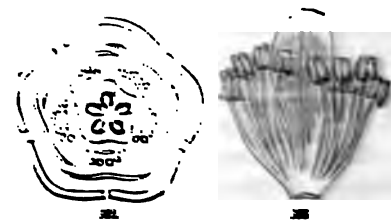
460. The *interposition* or *superposition* of parts which normally alternate in the flower has in some cases been regarded as a case of transverse chorisis; but it is susceptible of a simpler explanation. The principal case that occurs is that of the stamens, or the outermost circle of stamens, being placed directly before the petals

(in ordinary botanical language *opposite* the petals).

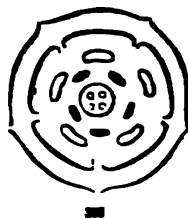
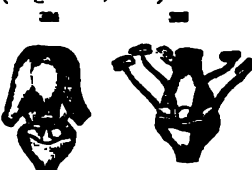
The Vine (Fig. 384-386)

and the Buckthorn families are good examples of this anomaly, as also is *Chytomia* in the Purslane family. And in Linden and

(Fig. 382, 383) stands be-



many of its allies a cluster of stamens before each petal, the American Lindens having also a petal-like scale in the centre of every cluster. The clusters must be viewed as multiplications of single stamens by collateral chorisis. The position of the stamens before the petals in these cases, as well as that of the numerous petals in certain double Camellias, arranged throughout in five vertical ranks, is most readily explained by supposing a return to the regular $\frac{1}{5}$ or five-ranked phyllotaxis of leaves (240).



461. In the genuine *Geranium* (Fig. 421) the position of the outer of the two sets of stamens before the petals evidently results from the abortion of an exterior circle (486); and perhaps this is the case in the Primrose family also. In the Barberry family there is an apparent anteposition of the sepals, petals, and stamens through-

FIG. 382. Diagram of the flower of the American Linden, in a cross-section of the bud. 383. A cluster of stamens with the petal-like body in the middle.

FIG. 384. Flower of the Grape, casting its petals before expansion. 385 The same, with the petals out: both show the glands distinctly, within the stamens. 386. Diagram of flower.

out. But this arises from the symmetrical augmentation of each set of organs into two circles, which in the expanded flower appear like one. In the flower-bud of the Barberry the calyx is seen to consist of two alternating circles of sepals, three in each; the corolla, of two circles of petals, three in each; the three exterior petals alternating as they should with the inner circle of sepals, and the three interior ones alternating with these. But when the flower opens, the six petals, spreading apparently as one whorl, are necessarily opposed to the six sepals; and the six stamens in two circles, which are still more confluent into one whorl, are equally opposed to these, taken six and six; although they really alternate in circles of three. In other words, decussating verticils of threes necessarily form six vertical ranks (251, 441). It is just the same in the Lily, Crocus, and most Monocotyledonous plants; where the perianth is composed of six similar leaves in two circles, and the andrœcium of six stamens in two circles, giving a regular alternation in threes; although, when taken by the casual observer as composed of two circles of six, it gives the appearance of six stamens before as many petals.

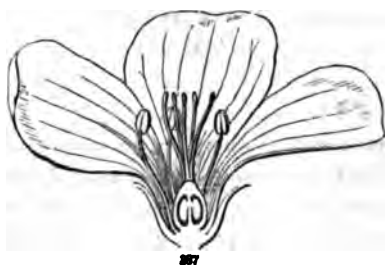
462. The Coalescence or union of the parts of the same whorl or set of organs is so frequent, that few cases are to be found in which it does not occur, to a greater or less extent, in some portion of the flower. When the sepals are thus united into a cup or tube, the calyx is said to be *monosepalous*, or, more correctly, *gamosepalous*; when the petals are united, the corolla is said to be *monopetalous*, or *gamopetalous*. The latter is the appropriate term, as it denotes that the petals are combined; but the former is in common use, although etymologically incorrect, as implying that the corolla consists of a single petal. The current names, in these cases, were given long before the structure was rightly understood. So, also, such a calyx or corolla is said to be *entire*, when the sepals or petals are united to their very summits; or to be *toothed*, *lobed*, *cleft*, or *parted*, according to the degree in which the union is incomplete; this language being employed just as in the case of the division of leaves (281). On the other hand, when the sepals are not united, the calyx is said to be *polysepalous*; and when the petals are distinct, the corolla is said to be *polypetalous*; that is, composed of several petals.

463. The union of the stamens with each other may occur either by their filaments, as in the Pea and most of the Pulse family, or by their anthers, as in the Sunflower and the whole Composite family, or

by both the filaments and the anthers, as in *Lobelia* and the *Gourd*. An account of the modes of such union, and of the terms employed to express them, may be found in Section VI. The union of the pistils is still more common than that of stamens, and is illustrated in Section VII.

464. The terms *union*, *cohesion*, and the like, must not be understood to imply that the organs in question were first formed as distinct parts, and subsequently cohered. This is seldom the case. The union is congenital; the members of a gamosepalous calyx, a gamopetalous corolla, &c. showed their union from the earliest period. The language we use has reference to our idea of these parts, as answering each to a single leaf. We might more correctly say that the several leaves of the same circle have failed to isolate themselves as they grew. The same remark applies to the analogous case of

465. *Adnation*, or *Consolidation*, the union of different circles of floral organs with one another. This may take place in various degrees. It presents the appearance of one circle or set of parts growing out of another, as the corolla out of the calyx, the stamens out of the corolla, or all of them out of the pistil; and therefore disguises the real origin of the floral organs from the receptacle or axis, in successive series, one within or above the other (421). The consideration of the flower as respects such consolidation, or its absence, gives rise to three terms which are much used in descriptive botany, and which the student should thoroughly understand, viz. *hypogynous*, *perigynous*, and *epigynous*.



466. The first of these terms applies to the case in which there is no adnation or consolidation of unlike parts. That is, when the calyx, corolla, and stamens are borne (i. e. *inserted*) on the receptacle, they are said to be *hypogynous* (from two Greek words meaning under

the pistil), as in *Buttercup*, *Flax* (Fig. 387), &c. The floral organs in such cases are also said to be *free*; which is the term opposed to

FIG. 387. Vertical section of a flower of the Common Flax, showing the normal or hypogynous insertion of parts.

the adhesion of one organ to another, as that of *distinct* is to the cohesion of the parts of the same whorl or set of organs. Thus, the stamens are said to be *distinct*, when not united with each other, and to be *free*, when they contract no adhesion to the petals, sepals, or pistils; and the same language is equally applied to all the floral organs. The word *connate* (born united) is applied either to the congenital union of homogeneous parts (as when we say that the two leaves of the upper pairs of the Honeysuckle are connate, Fig. 294, the sepals or stamens are connate into a tube, or the pistils into a compound pistil), or to the coalescence of heterogeneous parts (as that of the petals with the calyx, or of both with the pistil). But the word *adnate* belongs to the latter case only.

467. When such consolidation takes place, and the petals and stamens (which almost always accompany each other), or either of them, are inserted on the calyx, i. e. are adnate with the base of the calyx (as in the Cherry, Fig. 388, or Purslane, Fig. 389), they are said to be *perigynous* (literally, placed around the pistil). The real origin of the parts must be the same as in the former case, that is, the parts really belong to the receptacle, in successive circles, one above or within the other, first the sepals, then the petals, within these the stamens, and within or above these the pistils; but the true origin or position of some of the parts is here obscured by the adnation, at their base at least, of parts which are normally separate. In Fig. 388, the petals and stamens are adnate to the lower part of the calyx, but all are free from the pistil. But in Fig. 389, all four organs are consolidated below, as far as to the middle of the ovary.



FIG. 388. Vertical section of a flower of the Cherry, to show the perigynous insertion of the petals and stamens.

FIG. 389. Similar section of the flower of the Purslane, showing an adnation of parts with the lower part of the ovary.

487. In the Apple, Hawthorn (Fig. 389), and many other plants, the corolla-tube extends farther, and the calyx is minute and is



inverted and coherent with the whole surface of the ovary, which accordingly appears to be under the rest of the flower, instead of the uppermost and innermost part as it properly is. The earlier botanists called the flower, or calyx, in such cases, *superior*, and the ovary and fruit

inferior: and when an such corolla-tube occurs, the flower, or calyx, &c. was said to be *inferior*, and the ovary *superior*. But these terms should be superseded by the equivalent and much more appropriate expressions of *calyx adherent*, in the one case, and *calyx free*, in the other; or by that of *ovary coherent with the calyx*, and *ovary free from the calyx*, which is the same thing in other words.* More commonly the corolla and the stamens are adnate to the calyx to just where these parts all separate from the pistil; in which case they are still *perigynous*, or borne on the calyx. In some such cases, as in the Evening Primrose and Fuchsia, the tube of the calyx is prolonged far beyond the ovary, and the petals and stamens are inserted in it just below where it separates into its distinct lobes.

488. In other flowers the petals and the stamens are distinct at the line where the calyx separates from the top of the ovary, or are borne on the edge or face of a thickened disc (489) which crowns its summit, as in Arnica (Fig. 410), the Ivy, and all that family, in the whole Parsley family, the Cornel family, the Cranberry (Fig. 391), and the like. The stamens, &c., being then apparently borne on the ovary, are said to be *epigynous* (from two Greek words meaning "on the pistil").

* A floricult view at present is that the calyx in many cases (as in the Rose, Apple, &c.) actually begins at the place where it is distinct from the parts within, and that the so-called tube is the summit of the peduncle hollowed out, or developed around the pistil. This view can be correct in certain cases only, and the difference between it and the current view is really not so great as it seems.

FIG. 389. Flower of Hawthorn vertically divided, to show the calyx adnate to the ovary.

470. In some few plants the stamens continue this adnation a little further, and cohere with the style, either with its base only, as in some species of *Asarum*, or with its whole length, as in *Cypripedium* (Fig. 468) and the whole *Orchis* family. Then the flower is said to be *gynandrous*;—from two Greek words equivalent in meaning to stamens and pistil combined (519).

471. Irregularity. The flower is *irregular* when the parts of its different circles, or of one or



more of them, are not all alike in number, shape, or size. Irregularity may be the result, therefore, either of the *abortion* or *disappearance* of some parts, or of their *unequal development* or *unequal union*. The latter case may be first considered.

472. The Pea tribe affords a familiar illustration of *irregular* flowers arising from

the unequal size and dissimilar form of the floral envelopes; especially of the corolla, which, from a fancied resemblance to a butterfly in the flower of the Pea, Locust (Fig. 392), &c., has been called *papilionaceous*. The petals of such a corolla are distinguished by separate names; the upper one, which is usually most conspicuous, being termed the *vexillum*, *standard*, or *banner* (Fig. 392', *a*); the two lateral (*b*) are called *wings* (*alæ*), and the two lower (*c*), which are



usually somewhat united along their anterior edges, and together

f Cranberry divided lengthwise, showing the petals and stamens epi-

a flower of the common Locust-tree (*Robinia Pseudacacia*).

same, the petals displayed.

form a body in shape resembling the keel, or rather the narrow prow, of an ancient vessel, are named the *carina* or *keel*. The calyx of the same blossom is slightly irregular by the unequal union of parts, the two upper sepals being united higher than the other three. In *Baptisia* these two sepals are coalescent to the tip, or nearly so,

causing the calyx to appear as if formed of four sepals instead of five. In most *Lupines*, not only are the two upper sepals coalescent into one body nearly or quite to the tip, but the three remaining ones are likewise united into one body, on the lower side of the flower, thus giving the calyx the appearance of consisting of two petals in place of five. The ir-

regularity of papilionaceous flowers likewise affects the stamens, which, although of symmetrical number, viz. ten, or two circles, are in most cases unequally coalescent, nine of them being united by the cohesion of their filaments for the greater part of their length, while the tenth (the posterior) stamen is distinct; as is illustrated in the section on the stamens (518). But in *Amorpha* (Fig. 395), which belongs to the same tribe of plants, the ten stamens are united barely at their base; and there is a complete return to regularity in those of *Baptisia* (Fig. 394) and *Sophora*, which are perfectly distinct or separate. The *Violet* (Fig. 397) offers another very familiar form of irregular flowers; the irregularity belonging

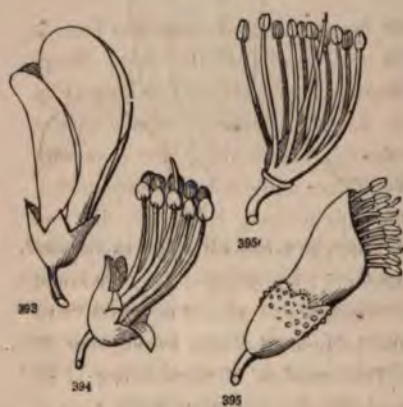


FIG. 393. Papilionaceous flower of *Baptisia*. 394. The same, with the petals removed, showing the ten distinct stamens.

FIG. 395. Flower of *Amorpha*. 396. The same, with the solitary petal removed, showing the slightly monadelphous stamens.

FIG. 396. Flower of *Viola sagittata*. 397. Its sepals and petals displayed.

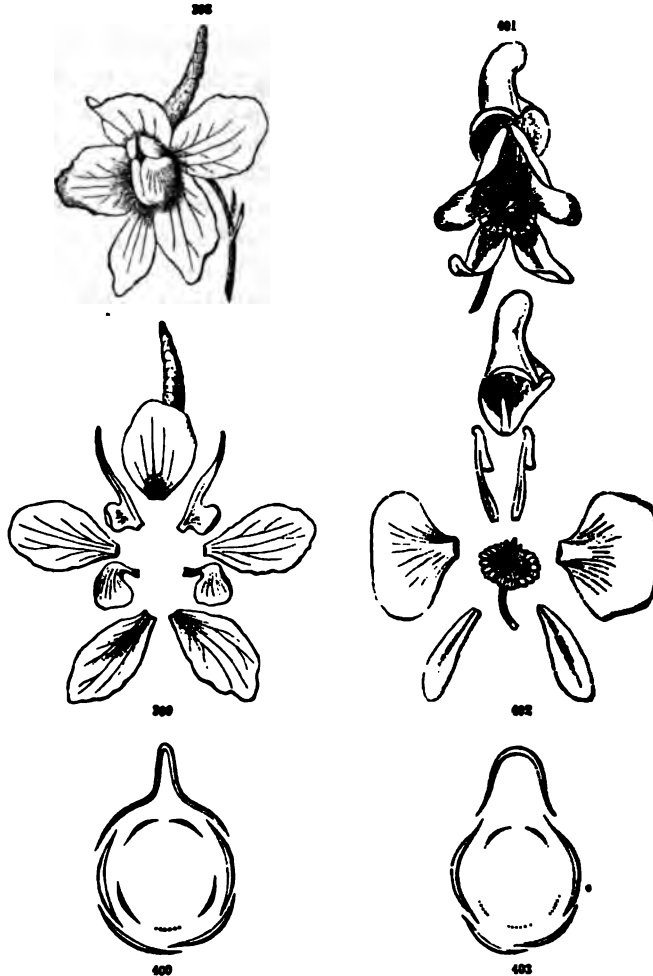
mainly to the corolla, the lower petal of which is prolonged backward into a sac or spur. The Larkspur and Monkshood (Fig. 398-402) are irregular both in the calyx and the corolla, not only by a diversity in the size and shape of homologous parts, but also by the suppression of some of them. We may therefore consider them under the next head.

473. Of irregular monopetalous flowers the most common form is the *bilabiate* or *two-lipped*, as in the corolla of the Sage, Snapdragon, and most of the large families to which they belong (Fig. 460): this, like the calyx of the Lupine, described above, arises from the unequal union of the parts. The same is the case with the two-lipped corolla of the Woodbine and other Honeysuckles, only here, instead of two lobes or petals forming the upper lip and three the lower, four petals enter into the composition of the upper lip, leaving only one for the lower (Fig. 861). The Trumpet Honeysuckle returns nearly to regularity again, the whole five petals being coalescent into a tube to near the top, leaving an almost equally five-lobed border. The corollas of Germander (Fig. 996) and of Lobelia (Fig. 902) are further irregular by a want of union on the upper side of the blossom: and the *ligulate* or open and strap-shaped corolla of Coreopsis (Fig. 325, c) and other Compositæ evidently answers to such a regular monopetalous corolla as a, split down on one side and outspread.

474. *Suppression or Abortion*, that is, the complete or the partial obliteration of some member, is a common cause of irregularity. The term *suppression* is used when parts which belong to the plan of the blossom do not actually appear in it. The term *abortion* is applied not only to such disappearance, but to partial obliteration, as where a stamen is reduced to a naked filament, or to a mere rudiment or vestige, answering to a stamen and occupying the place of one, but incapable of performing its office. Such obliteration, whether partial or complete, may affect either a whole circle of organs or merely some of its members. The former interferes with the completeness of a flower, and may obscure the normal order of its parts. The latter directly interferes with the symmetry of the blossom, and may be first considered.

475. *Suppression of some Parts of a Circle of Organs.* The Larkspur and Aconite or Monkshood furnish good examples of flowers which are both irregular and symmetrical. The calyx of the Larkspur (Fig. 398, 399) is irregular by reason of the dissimilarity of the five

sepals, one of which, the uppermost and largest, is prolonged posteriorly into a long and hollow spur. Within these, and alternate with



them as far as they go, are the petals, only four in number, and these of two shapes, the two upper ones having long spurs which are re-

FIG. 398. Flower of a Larkspur. 399. The five sepals (outer circle) and the four petals (inner circle) displayed. 400. Ground-plan of the calyx and corolla.

FIG. 401. Flower of an Aconite or Monkshood. 402. The five sepals and the two small and curiously-shaped petals displayed: also the stamens and pistile in the centre. 403. Ground-plan of the calyx and corolla; the dotted lines, as in Fig. 400, representing the suppressed parts.

ceived into the spur of the upper sepal; the two lateral ones having a small but broad blade raised on a stalk-like claw; and the place which the fifth and lower petal should occupy (marked in the ground plan, Fig. 400, by a short dotted line) is vacant, this petal being suppressed, thereby rendering the blossom unsymmetrical. In Aconite, (Fig. 401, 402) the plan of the blossom is the same, but the uppermost and largest of the five dissimilar sepals forms a helmet-shaped or hood-like body; and as to the petals, three are wanting altogether (their places are shown by the dotted lines in the ground plan, Fig. 403); the two upper ones, which extend under the hood, only remain, and these are so reduced in size and so anomalous in shape that they would not ordinarily be recognized as petals. One of them enlarged is exhibited in Fig. 404. Petals, &c. of this and other extraordinary forms were termed by Linnaeus *Nectaries*, an unmeaning or misleading name, as they are no more likely to secrete honey than ordinary petals are.



476. The papilionaceous corolla (472) becomes strikingly unsymmetrical by suppression in *Amorpha* (Fig. 395). Here the corolla is uniformly reduced to a solitary petal (the standard), the other four petals being totally obliterated. This obliteration is foreshadowed in *Erythrina herbacea* of the Southern States, and other species, in which all the petals except the standard are small and inconspicuous. While the blossom of the common Horsechestnut, although irregular, is symmetrical, so far as respects the calyx and corolla, that of our nearly related Buckeyes generally wants one of the five petals, a vacant place on the anterior side of the flower indicating its absence.

477. The suppression or abortion of some of the stamens requisite to the symmetry of the blossom is very common. According to the ordinary view, the six stamens of the flowers of the Mustard family (Fig. 405, 406), where the sepals and petals are in fours, is explained by supposing that, out of two circles of stamens, four in each, two stamens of the outer circle are

FIG. 404. One of the petals of an Aconite or Monkshood, enlarged.

FIG. 405. Flower of Mustard 406. Its six stamens and the pistil, enlarged.

suppressed. But we incline to the opinion that this sort of flower is rendered unsymmetrical, not by the suppression of two short stamens, but by the chorisis or division of the two stamens each into a pair (456, Fig. 368).

478. Most flowers which are irregular by the unequal union of



the petals, especially those with a *bi-labiate* corolla (473, 511), are likewise unsymmetrical by the abortion of one or more of the stamens. In the Catnip, Balm, &c., and in the Snapdragon, Monkey-flower, Foxglove, and the like, as also in *Gerardia* (Fig. 407), where the corolla is only slightly irregular, four stamens occupy their proper places alternate with its lobes, but the fifth stamen is altogether wanting. In its place, however, the corolla of the Figwort, belonging to the same family as the Snapdragon and *Gerardia*, bears a small scale, and that of *Chelone* and *Pentstemon* (Fig. 408) bears an antherless filament, which, from its position, must be the wanting stamen, in an abortive state; and in one species it has actually been found with a perfect or an imperfect anther, completing the symmetry of the flower. The four perfect stamens in these cases are of unequal length, two of them being longer than the other two (i. e. they are *didynamous*, 520).

The two shorter stamens also disappear in many such plants, as in *Gratiola* or Hedge-Hyssop, — sometimes leaving vestiges in their place, and sometimes not; also in Sage, Horse-Mint, and the like. Here three stamens out of five are suppressed. So they commonly

FIG. 407. Corolla of *Gerardia purpurea* laid open, with the four stamens the place which the fifth should occupy indicated by a cross.

FIG. 408. Corolla of *Pentstemon grandiflorus* laid open, with its four stamens, and a sterile filament in the place of the fifth stamen.

FIG. 409. Corolla of *Catalpa* laid open, with two perfect stamens and the vestiges of three abortive ones.

are in the blossom of *Catalpa* (Fig. 409), but their vestiges remain in the form of small sterile filaments, two of which, however, occasionally bear anthers, either perfect or rudimentary.

479. The suppression of a portion of the pistils required to complete the symmetry of the flower is exceedingly common. The tendency to obliteration seems to increase as we advance towards the centre of the blossom, owing, doubtless, to the greater pressure exerted on the central parts of the bud, and the progressively diminished space the organs have to occupy on the conical receptacle. Thus, while the corolla, when present at all, almost always consists of as many leaves as the calyx, the members of the staminal circle or circles are frequently fewer in number, and the pistils are still more commonly fewer, excepting where the axis is prolonged for the reception of numerous spiral cycles. Thus, the pistils, which present the symmetrical number in *Sedum*, and all plants of that family (Fig. 334, 335, 355, 361), are reduced to two, or rarely three, in the allied *Saxifrage* family, while the other floral circles are in fives. So, in the *Wild Sarsaparilla* (Fig. 410) and *Spikenard*, the flowers are pentamerous throughout, although the ovaries of the five pistils are united into one; but they are reduced to three in the *Ground-nut*, and to two in the *Ginseng*, belonging to the same genus, as also in all *Umbelliferous* plants. Although the pistils are indefinitely augmented in the *Rose*, *Strawberry*, and the greater part of *Rosaceous* plants, or are of the normal number five in *Spiraea*, yet there are only two in *Agrimonia*, one or rarely two in *Sanguisorba*, and uniformly one in the *Plum* and *Cherry* (Fig. 388), although the flowers of the whole order are formed on the pentamerous, or sometimes the tetramerous plan, and with a strong tendency to augmentation of all the organs. And the *Pulse* family has, almost without exception, five members in its floral envelopes, and ten, or two circles, in its stamens, but only a single pistil (Fig. 358).

480. **Suppression of one or more whole Circles.** A complete flower, as already remarked (416), comprises four whorls or sets of organs; namely, calyx, corolla, stamens, and pistils. When any of these four circles or kinds of organs are wanting, the flower is said to be *incomplete*. The non-production of any one or more of the whorls is not uncommon. The calyx, however, is seldom if ever wanting when the corolla is present, or rather, when the floral envelopes consist of only one whorl of leaves, they are called *calyx*, whatever be their appearance, texture, or color, unless it can somehow be shown

that an outer circle is suppressed.* For since the calyx is frequently delicate and petal-like (in botanical language *petaloid* or *colored*), and the corolla sometimes greenish or leaf-like, the only real difference between the two is, that the calyx represents the outer, and the corolla the inner series; and even this distinction becomes more or less arbitrary when either, or both, of these organs consist of more than one circle. The apparent obliteration of the calyx in some cases is owing to the entire cohesion of the



tube with the ovary, and the reduction of the free portion, or limb, to an obscure ring or border, either slightly toothed or entire, as in Aralia (Fig. 410), Fedia (Fig. 882), Cornus, the fertile flowers of Nyssa, &c. In Compositæ, the partially obliterated limb of the calyx, when present at all, consists of scales, teeth, bristles, or a ring of slender hairs (as in the Thistle), and receives the name of *pappus*.

481. The petals, however, are frequently absent; when the flower is said to be *apetalous*, as in the Anemone (Fig. 411), Clematis, Caltha, &c., in the Crowfoot family, other genera of which are furnished with both calyx and corolla; and as in some species of Buckthorn, while others have manifest although small petals. They are constantly wanting in a large number of families of Exogenous plants, which on this account form the division *Apetalæ*. When the calyx is present while the corolla is wanting, the flower is said to be *monochlamydeous*, that is, with a perianth (417) or floral envelope of only one kind; as in the cases above mentioned.



* In our Northern *Zanthoxylum* the monochlamydeous perianth which is present may, however, be justly held to be the corolla, and not the calyx, because the five stamens alternate with it, just as they do with the undoubted petals of *Z. Carolinianum*: in this case, therefore, we may say that the calyx and not the corolla, is suppressed. See *Genera Illustrata*, Vol. 2, p. 148, tab. 15.

FIG. 410. Flower of *Aralia nudicaulis*, vertically divided; the limb of the calyx obsolete.
FIG. 411. Flower of *Anemone Pennsylvanica*; apetalous, the calyx petaloid.

482. In some flowers, moreover, as in the Lizard's-tail (Fig. 412), both the calyx and the corolla are entirely wanting, and the blossom is *achlamydeous*, i. e. destitute of any perianth or floral envelopes whatever. Having the essential organs, viz. the stamens and pistils, however, this flower also is *perfect* (*hermaphrodite*, or *bisexual*), although *incomplete*.



483. The abortion of all the stamens or all the pistils of a flower is common enough, as well in flowers that have as in those that have not complete floral envelopes; but whenever either of these essential organs are abortive or wanting in some blossoms, they are present in others of the same species, either on the same or on different individuals. Flowers of this kind having stamens only or pistils only are said to be *separated*, *diclinous*, or *unisexual*. And the flower which has the stamens but no pistils, or only imperfect ones, is said to be *staminate*, *sterile*, or *male*; while that provided with pistils, but with no stamens, or only imperfect ones, is *pistillate*, *fertile*, or *female*. Not to multiply examples, in Smilax and in Menispermum (Fig. 413, 414) we have good instances of separated flowers in which the abortion is confined to the stamens or the pistils, the floral envelopes being present and



FIG. 412. Flower of Lizard's-tail (*Saururus cernuus*), magnified.
 FIG. 413. A staminate flower of *Menispermum* or Moonseed. 414. A pistillate flower of the same. The latter has six or seven, mere vestiges of pistils.
 FIG. 415. A branch of *Smilax*. 416. A single staminate flower detached and magnified. 417. A pistillate catkin of the same species. 41

complete. And in the Willow (Fig. 415-418) we have separated flowers extremely simplified by abortion. The flowers are crowded in catkins, each one in the axil of a bract: the staminate flowers consist of a few stamens merely, in this species of only two (Fig. 416), and the pistillate, of a pistil merely (Fig. 418). That is, the flowers are wholly destitute of calyx and corolla (unless a little glandular scale on the upper side should be a rudimentary perianth of a single piece), and in one set of blossoms the stamens are also suppressed; in another, the pistils. The stamens vary in number in different species, from two to five. If there were only one of the latter, an instance would be afforded of flowers reduced, not merely to one kind of organ, but to a single member. Now there is one species of Willow, which appears to have its sterile blossoms reduced to a solitary stamen. It



419

has therefore been named *Salix monandra*. But on inspection this seemingly single stamen is found to consist of two united with each other quite to the top (Fig. 419). Here, as in many other cases, the normal condition of the flower is not only much altered by the suppression of most of the organs, but disguised by the coalescence of those that remain.

484. In separated flowers the two kinds of blossoms may be borne either upon different parts of the same individual, or upon entirely different individuals. The flowers are said to be *monœcious* when both kinds are borne on the same plant; as in Indian Corn, the Birch, the Oak, Beech, Hazel, Hickory, &c.: and they are called *diœcious* when borne by different individuals; as in the Willow and Poplar, the Sassafras, the Prickly Ash, the Hemp and Hop, Moonseed (Fig. 413, 414), &c. Occasionally, while some of the flowers are staminate only, and others pistillate only, a portion are perfect, the different kinds occurring either on the same or different individuals; as in most Palms, in many species of Maple, &c.: plants with such flowers are said to be *polygamous*.

485. In some of the blossoms of certain plants both stamens and pistils are wanting. This is the case with those that occupy the margin of the cymes of the Hobblebush and some other *Viburnum*s, and of *Hydrangea* (Fig. 420), or even with the whole cluster in cultivated monstrous states, as in the 'Snowball' or *Guelder-Rose* of the gardens (*Viburnum Opulus*). Here the enlarged corolla

FIG 419 A staminate flower of *Salix purpurea* (or *monandra*), with the stamens coalescent (monadelphous and syngenesious), so as to appear like a single one.

make the whole blossom. Such flowers, being neither staminate nor pistillate, are said to be *neutral*. In so-called compound flowers (394) the strap-shaped marginal flowers are sometimes neutral, as in *Coreopsis* (Fig. 324, 325), Mayweed, and Sunflower. In some Grasses and other plants such neutral flowers want the floral envelopes also, or are reduced to an abortive rudiment.



486. The suppression or abortion of a whole circle of organs in a symmetrical flower does not destroy its symmetry, if we take note of the absent members. Thus a monochlamydeous flower, with a single full circle of stamens, usually has the latter placed opposite the leaves of the perianth, that is, of the calyx, the corolla or intervening circle having failed to appear. But when, with the abortion of the primary circle, say of the stamens, we have an augmentation of one or more additional circles of the same kind of organ, the law of alternation appears to be violated; the stamens that are present, or the outer circle of them, standing before the petals, instead of alternate with them. It is customary to assume this explanation for all cases of the anteposition of the stamens to the petals, whether in the Primrose family, in Claytonia, in the Vine (Fig.

FIG. 420. Cyme of *Hydrangea arborescens*, with the large marginal flowers neutral

384), or the Buckthorn, &c. But more probable explanations for some such cases have already been given (459, 460). It can no longer be deemed sufficient to assume the obliteration of a normal floral circle, and the production of a second one, when no traces of the former can be detected and no clear analogy shown with some strictly parallel instance. Yet we may confidently apply this view when we do find traces of obliterated organs, as in the *Geranium* family, for example. The pentamerous flower of *Geranium* exhibits ten stamens, plainly occupying two rows, the five of the exterior circle shorter than the others. One set of these stamens alternates with the petals, the other is opposed to them. But on close examination, we perceive that it is the *inner* circle of stamens that alternates with the petals; those of the *outer* circle stand directly before them. This is a not uncommon case where there are just twice as many stamens as there are petals or sepals. In this instance the



explanation of the anomaly is furnished by the five little bodies, called by the vague and convenient name of *glands*, which stand on the receptacle between the petals and the stamens, and regularly alternate with the former. They accordingly occupy the exact position of the original staminal circle: wherefore, as situation is the best indication of the nature of

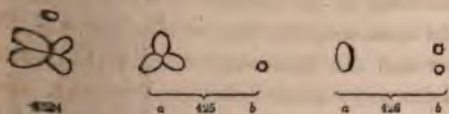
organs, we may regard them as the abortive rudiments of the five proper stamens, here obliterated. In the annexed diagram (Fig. 421) these are accordingly laid down in the third circle, as five small oval spots, slightly shaded. The actual stamens consequently belong to two augmented circles, those of the exterior and shorter set of which (represented by the larger, unshaded figures), normally alternating with the glands, are of course opposed to the petals, and those of the inner and larger set, normally alternating with the preceding, necessarily alternate with the petals. This view is further elucidated by the closely allied genus *Erodium*, where all the parts are just the same, except that the five exterior actual stamens are shorter still, and are destitute of anthers; that is, the disposition to suppression, which has caused the obliteration of the primary circle of stamens and somewhat reduced the second in *Geranium*, has in *Erodium*

FIG. 421. Diagram (cross-section) of the flower of *Geranium maculatum*, exhibiting the relative position of parts, especially the glands alternate with the petals, and the two rows of stamens within them.

rendered the latter abortive also, leaving those of the third row alone to fulfil their proper office. And in a South African genus, *Monsonia*, five stamens actually occur in the place of these glands, making fifteen real stamens, or three circles. The general plan of the flower is the same in the Flax family, except that the glands which answer to the outer rank of stamens are still less conspicuous, and those of the next circle are reduced to small abortive filaments, or to minute teeth in the ring formed by the union of all the filaments into a cup at the base, leaving five perfect stamens, which, though they alternate with the petals indeed, belong to a third circle (Fig. 422, 423). In a few species of Flax, this second circle of stamens is perfectly obliterated, so that no vestige is to be seen.



487. The complete suppression of two or three of the circles belonging to the complete flower, and of a part of the members of what remains, reduces a blossom to the last degree of simplicity. Among the simplest of perfect flowers are those of *Callitriche* (Fig. 1136 - 1138), which have neither calyx nor corolla; and only one stamen, as is expressed in the annexed diagram (Fig. 424); yet the four-lobed pistil shows that the blossom was constructed on the plan of four. And even this stamen is suppressed in certain



blossoms, and the pistil in others. In *Euphorbia* (also to be illustrated under the family to which it belongs, Fig. 1143) the flowers are always separated, and the staminate blossom is reduced to a single stamen, the pistillate to a single three-lobed pistil (Fig. 425). And in the Willow, as already noticed (438), the pair of stamens which represents one sort of blossom, and the single pistil which represents the other, are widely separated, being borne on distinct trees.

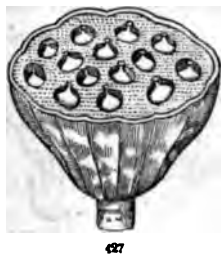
FIG. 422. Flower of *Linum perenne*. 423. Its stamens and pistils enlarged.

FIG. 424. Diagram of a perfect flower of *Callitriche*, with no floral envelopes, one stamen, and a four-celled pistil.

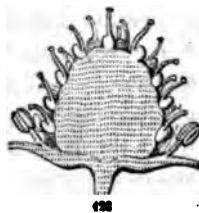
FIG. 425. Diagram of the monocious flowers of *Euphorbia*: a, the pistillate flower reduced to a mere three-celled pistil; and b, one of the staminate flowers reduced to a single stamen.

FIG. 426. Diagram of the dioecious flowers of the Willow: a, one of the pistillate flowers reduced to a solitary pistil; b, a staminate flower reduced to a pair of stamens.

488. Unusual States of the Receptacle. The receptacle (421) is commonly small, short, and inconspicuous, being merely the extremity of the flower-stalk upon which the several organs are inserted (Fig. 343). Sometimes, however, it is remarkably enlarged or elongated. A striking instance of an enlarged receptacle is found in *Nelumbium*, where it is dilated into a large top-shaped body, nearly enclosing the pistils in separate cavities (Fig. 427). Whenever the pistils of a flower are very numerous, the receptacle is more or less enlarged for their



insertion, as in *Magnolia*, the Raspberry and Blackberry, &c. In the Strawberry the enlarged and conical receptacle (Fig. 428), bearing the pistils on its surface, becomes the edible portion in fruit. In the Rose (Fig. 429) the receptacle is deeply concave, instead of convex, being urn-shaped, invested by the adnate tube of the calyx, and bearing the petals and stamens on its border and the numerous pistils on its whole hollow surface (Fig. 429). It is much the same in *Calycanthus* (Fig. 814-819). In *Geranium*, and



many allied plants, the receptacle is prolonged between the ovaries, and coheres with their styles (Fig. 430); these, however, separating at maturity (Fig. 431). In Umbelliferous plants a similar but more slender prolongation of the receptacle is extended upwards between the contiguous faces of the two united ovaries which form the fruit

FIG. 427. The enlarged, top-shaped receptacle of *Nelumbium*, bearing the pistils, immersed in hollows of its upper face.

FIG. 428. Longitudinal section of a young strawberry, enlarged.

FIG. 429. Similar section of a young Rose-hip.

FIG. 430. Gynoecium of *Geranium maculatum*, or Cranesbill, enlarged.

FIG. 431. The same at maturity, with the five pistils splitting away from the long beak or receptacle and hanging from its top by their styles.

in that family. Occasionally one or more of the internodes between successive floral circles elongate; as between the calyx and the corolla in Pinks, and especially in *Silene*, forming a stalk within the calyx, on which the rest of the flower is raised (Fig. 432); while in many *Gentians* the internode above the circle of stamens is developed, raising the pod on a stalk of its own. This is a common case in the *Caper* family; in which the genus *Gynandropsis* (Fig. 433) exhibits a remarkable development of the whole receptacle. It is enlarged into a flattened disk, where it bears the petals, and is then prolonged



into a conspicuous stalk which bears the stamens, — or rather, to which the bases of the stamens are adnate, — and then into a shorter and more slender stalk for the pistil; thus separating the four circles or sets of organs, like so many whorls of verticillate leaves. The general name for this kind of stalk, as contradistinguished from the pedicel or stalk of the flower, is the *STIPE*; and whatever organ or set of organs is thus elevated is said to be *stipitate*. Whenever it is necessary to particularize the portion of the receptacle thus developed, the stipe is termed the *Anthophore* when it appears just above the calyx, and elevates the petals, stamens, and pistils; the *Gonophore*, when it supports both the stamens and pistils; and the *Gynophore*, *Gynobase*, or *Carpophore*, when it bears the gynæcium alone. The stalk which sometimes supports each simple pistil of the gynæcium (as in *Coptis* or the Goldthread) is called a *Thecaphore*. This, however, does not belong to the receptacle at all, but to the pistil itself, and is homologous with the leafstalk.



489. A *Disk* is a part of the receptacle, or a growth from it, enlarged under or around the pistil. Like the other parts of the flower,

FIG. 432. Section of a flower of *Silene Pennsylvanica*, showing the stipe or *anthophore*.

FIG. 433. Flower of *Gynandropsis*, with a remarkably elongated receptacle.

FIG. 434. Disk of the Orange, underneath the pistil (hypogynous).

it is *hypogynous* (466), when free from all union either with the pistil or the calyx, as in the Rue and the Orange (Fig. 434). It is *perigynous* (467); when it adheres to the base of the calyx, as



in the Buckthorn (Fig. 435, 436); and where the calyx is adnate to the ovary, as in the Apple, Hawthorn (Fig. 390), &c., there is commonly a disk interposed between the two. This disk is sometimes expanded on

the summit of such an ovary, when it is said to be *epigynous* (469), as in Cornus, and all Umbelliferous plants.

SECT. V. THE FLORAL ENVELOPES IN PARTICULAR.

490. Their Development, or Organogeny, first requires a brief notice. The flower-bud is formed in the same way as the leaf-bud; and what has been stated as to the formation of the leaves of the branch (273) equally applies to the leaves of the flower. The sepals are necessarily the earliest to appear, which they do in the form of so many cellular protuberances, at first distinct, inasmuch as then their tips only are eliminated from the axis. Each one may complete its development separately, like an ordinary leaf, when the sepals remain distinct. Or the lower and later-eliminated portions of the forming organs of the circle coalesce as they grow into a ring, which, further developed in union, forms the *cup* or *tube* of the *gamophyllous calyx*. In some cases, it would appear that the sepals may at first grow separately, and afterwards, though only at a very early period, coalesce by the cohesion of their contiguous parts. The several parts of an irregular calyx are at first equal and similar; the irregularity appears in their subsequent unequal growth. The petals or parts of the corolla originate in the same way, a little later than the sepals. Their coalescence in the gamopetalous corolla is congenital; the ring which forms its tube appearing nearly as early as do the slight projections which become its lobes and answer to the summits of the component petals. The rudiments of the petals are visible earlier than those of the stamens: but their growth is at first

FIG. 435. Flower of a Buckthorn, showing a large perigynous disk. 436. Vertical section of the same.

retarded, so that the stamens are earlier completed, and their anthers surpass them, or often finish their growth, while the petals are still minute scales: at length they make a rapid growth, and enclose the organs that belong above or within them. Unlike the sepals in this respect, the base of the petal is frequently narrowed into a portion which corresponds, more or less evidently, to the petiole (the *claw*), and which, like the petiole, does not appear until some time after the blade or expanded part; the summit being always the earliest and the base the latest portion formed. As the envelopes of the flower grow and expand, those of each circle adapt themselves to each other in various ways, and acquire the relative positions which they occupy in the flower-bud. Their arrangement in this state is termed

491. Their *Æstivation* or *Præfloration*. The latter would be the preferable term; but the former is in common use; the word *Æstivation* (literally the summer state) having been devised for the purpose by Linnaeus;—for no obvious reason except that he had already applied the name of *Vernation* (the spring state) to express the analogous manner in which leaves are disposed in the leaf-bud. The same terms are employed, and in nearly the same way, in the two cases, but with some peculiarities. As to the disposition of each leaf taken by itself, the corresponding terms of *vernation* (257) wholly apply to *æstivation*. The arrangement in the bud of the several members of the same floral circle in respect to each other, is of much importance in systematic botany, on account of the nearly constant characters that it furnishes, and also in structural botany, from the aid it often affords in determining the true relative superposition or succession of parts on the axis of the flower, by observing the order in which they overlie or envelope each other.

492. The various forms of *æstivation* that have been distinguished by botanists may be reduced to three essential kinds, namely, the *imbricative*, the *contorted* or *convolutive*, and the *valvular*.*

493. *Imbricative* *æstivation*, in a general sense, comprises all the modes of disposition in which some members of a floral circle are exterior to the others, and therefore overlie or enclose them in

* We should properly say of the *æstivation* that it is *imbricative*, *convolutive*, *valvular*, &c., and of the calyx and corolla, or of the sepals, &c., that they are *imbricate* or *imbricated*, *convolute*, *valvate*, &c. in *æstivation*; but such precision of language is seldom attended to.

the bud. This must almost necessarily occur wherever the parts are inserted at distinguishably different heights, and is the natural result of a spiral arrangement. The name is most significant when successive leaves are only partially covered by the preceding, as in Fig. 207. Here they manifestly *break joints*, or are disposed like tiles or shingles on a roof, as the term *imbricated* denotes. It is therefore equivalent to the *spiral* arrangement: and, on the other hand, we properly apply the term *imbricated* to any continuous succession of such partly overlying members; as when we say of appressed and crowded leaves that they are imbricated on the stem, or thus express the whole arrangement of the scales of a bud (Fig. 153), or a bulb (Fig. 172), or of a catkin or cone (Fig. 209). The alternation of the petals with the sepals, &c. necessarily renders the floral envelopes likewise imbricated in the bud, taken as a whole. But in proper æstivation, what we have to designate is the arrangement of the parts of the same floral circle (say the five sepals or the five petals) in respect to each other.

494. Now when the sepals or the petals are three in number, and are regularly imbricated in the bud, as in Fig. 437, the three leaves are arranged just as in three-ranked phyllotaxis (238, Fig. 203); that is, with the first

petal exterior to the others, the second is covered by the first on one side while it covers the third on the other. When they are five (as in the calyx of *Geranium*, Fig. 439), they are disposed just as in five-ranked or quincuncial phyllotaxis with the axis shortened (240, Fig. 206); viz. two leaves are exterior, two wholly interior, and one (the third) with one edge covered by No. 1 on one side while it covers No. 5 with its other edge. So that this, the regular mode of imbrication when the parts are in fives, is termed *quincuncial* æstivation, or the parts are said to be *quincuncially*

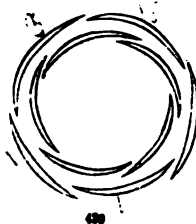
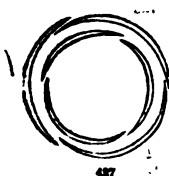


FIG. 437. Diagram of a three-leaved (trimerous) calyx and corolla, both imbricated in æstivation.

FIG. 438. Diagram of the æstivation of three petals (or one circle of the petals) of *Magnolia*, similarly imbricated, but strongly enwrapping, each making nearly a circle.

FIG. 439. Diagram of the imbricative æstivation of the calyx and the convolutive æstivation of the corolla of *Geranium*; the sepals numbered.

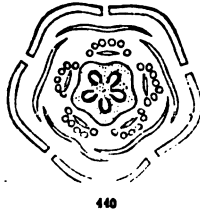
imbricated. We have here the advantage of being able to number the successive sepals, or petals, since the third leaf is not only recognizable by its intermediate position, but also indicates the direction in which the spiral turns (Fig. 206 and Fig. 439).

495. It must be recollected, in the comparison, that the parts of successive cycles are superposed in the foliage, while those of the floral circles alternate. Regular imbrication in the 4-merous flower gives two outer and two inner members in æstivation (as in the calyx of Cruciferous blossoms, Fig. 367), on the principle of two decussating pairs of leaves (441); or it may sometimes be referable to a modification of some alternate spiral arrangement.

496. The degree of overlapping depends upon the breadth of the parts and the state of the bud; it naturally grows less and less as the bud expands and is ready to open. It is from the full-grown flower-bud, just before *anthesis* (or the opening of the blossom), that our diagrams are usually taken; in which the parts are represented as moderately or slightly overlapping. The same overlapping carried to a greater extent will cause the outer leaf to envelope all the rest, and each succeeding one to envelop those within; as shown in Fig. 438 from one circle of petals of a *Magnolia* taken in an early state of the bud. To this, however, has not improperly been applied the name of *convolute*, from its similarity to the convolute veneration of the leaves of the branch (257), similarly rolled up one within the other. But it is practically inconvenient, and wrong in principle, to designate different degrees of the very same mode by distinct names; furthermore, it is to the next general mode of æstivation that the name of *convolute* is more commonly applied, at least in recent systematic botanical writings.

497. There are numerous cases of imbricative æstivation, especially in irregular flowers, where the overlapping of parts does not altogether accord with what must needs be their order of succession on the axis. In the 5-merous calyx and corolla of all truly papilionaceous flowers, for example, one edge of the sepal or the petal No. 2 is placed under, instead of over, the adjacent edge of No. 4, in consequence of which three, instead of only one, of the leaves have one edge covered and the other external; as is shown in Fig. 358. Since, in the corolla of this kind of blossom, the exterior petal, here the vexillum (472), is the larger, and at first embraces all the rest, this modification of imbricative æstivation has received the name of *vexillary*. As nearly the same thing occurs

in the Violet, it is probably caused by some slight dislocation that takes place during the early growth of organs in the irregular blossom. It is not restricted to irregular flowers, however, but occurs

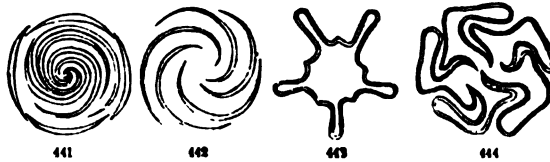


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as a casual variation, or perhaps more frequently than the quincuncial, in the regular corolla of the Linden (as is shown in Fig. 440). A slight obliquity in the position of the petal No. 2, assumed at an early period, would account for the whole anomaly. That this suggests the true explanation is almost demonstrated by the varying æstivation of the corolla of the

Linden; in which the same bunch of blossoms often furnishes instances of regular quincuncial imbrication, of the modification here referred to, and of a similar disposition of the fifth petal, throwing one of its edges outwards also. If the first petal were also to partake of this slight obliquity, the imbricative would be completely converted into what is variously named

498. The *contorted*, *twisted*, or *convolutive* æstivation (Fig. 439, 441, the corolla, and 442). In this mode, the leaves of the circle are all, at least apparently, inserted at the same height, and all occupy the same relative position: one edge of each, being directed obliquely inwards, is covered by the adjacent leaf on that side, while the other covers the corresponding margin of the contiguous leaf on the other side. This is owing to a torsion or twisting of each member on its axis early in its development; so that the leaves of the floral verticil, instead of forming arcs of a circle, or sides of a polygon



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having for its centre that of the blossom, severally assume an oblique direction, by which one edge is carried partly inward and the other outward. This contorted æstivation is rare in the calyx, but com-

FIG. 440. Diagram of the plan and æstivation of the flower of the Linden.

FIG. 441. Diagram of the imbricated calyx of Wallflower (two outer and two inner sepals), and within the strongly contorted or convolute corolla. 442. Corolla of the latter more open. 443. Cross-section of the plaited tube of the corolla of Campanula. 444. Similar section of the plaited and supervolute corolla of Convolvulus.

mon enough in the corolla. When this obliquity of position is strong, the petals themselves are usually oblique, or unequal-sided, from the lesser growth of the overlapped side. This is well seen in the petals of most Malvaceous plants, and in those of the St. Johnswort. In the Pink, however, and in many other instances, the petals are symmetrical, although strongly convolute in æstivation. When the petals are broad, this convolute arrangement is frequently conspicuous in the fully expanded flower, as well as in the bud. The convolution in the bud is often so great, that the petals appear as if strongly twisted or rolled up together, each being almost completely overlapped by the preceding, so that they become *convolute* nearly in the sense in which the term is used in veneration; as in the Wall-flower (Fig. 441, 442). Although there is some diversity of usage, the terms *convolute* and *contorted* in æstivation are now for the most part employed interchangeably, or nearly so.

499. The *valvular* or *valvate* æstivation is that in which the parts of a floral circle are placed in contact, edge to edge, throughout their whole length, without any overlapping, as in the calyx of the Mallow and Linden; Fig. 440. Here the members of the circle stand in an exact circle, no one being in the least degree lower or exterior. The edges of the sepals or petals in this case are generally abrupt, or as thick as the rest of the organ; by which mark the valvate æstivation may commonly be recognized in the expanded flower.

500. By inflexion of the edges, the valvate æstivation passes by gradations into the *induplicate* (Fig. 445), and this, when the margins are in-rolled, into the *involute* (Fig. 446), as is exemplified by the calyx of different species of Clematis. On the other hand, the valvate calyx of many Malvaceous plants has the margins projecting outwards into salient ridges, or is *reduplicate*, in æstivation.

501. In the Mignonette, and some other flowers, the æstivation is *open*; that is, the calyx and corolla are not closed at all over the other parts of the flower in the bud.

502. The form of the tube of the calyx or corolla in the bud sometimes has to be considered. Sometimes it is *plicate*, or *plaited* lengthwise; and the plaits may be turned either inwards, as in the

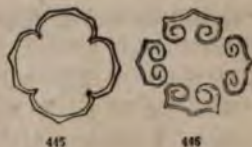


FIG. 445. Diagram of the valvate-induplicate æstivation of the calyx of Clematis Virginiana. 446. Same of Clematis Viticella, the margins involute.

corolla of Gentians, or outwards, as in that of Campanula (Fig. 443). When these plaits are laid over one another in a convolute manner, as in the unopened corolla of the Morning-Glory (Fig. 444) and Stramonium (Fig. 447, 448), the aestivation is said to be *supervolute*.



503. The direction of the spire or the overlapping of parts may be either from left to right, or from right to left; and this direction is generally uniform. In indicating the direction, it is most natural to suppose the observer to stand before the flower-bud. DeCandolle, indeed, supposes the observer to occupy the centre of the flower, which would reverse the direction; but the former is the prevalent view. The direction is frequently reversed in passing from the calyx to the corolla, sometimes with remarkable uniformity; while again the two occur almost indifferently in many cases. The *kind* of aestivation, although often the same both in the calyx and corolla, — as in Parnassia (Fig. 381) and Elodea (Fig. 375), where both are quincuncially imbricated, — is as frequently different; and the difference is often characteristic of families or genera. Thus, the calyx is valvate and the corolla convolute in all Malvaceæ; the calyx imbricated and the corolla convolute in Hypericum, in the proper Pink tribe, &c. Solitary exceptions now and then occur in a family. Thus, the corolla in Rosaceæ is imbricated, so far as known, except in Gillenia, where it is convolute. In general it may be said, that the aestivation of the corolla is less constant than that of the calyx.

* 504. The Calyx. In treating of the general structure and diversities of the flower, we have already noticed the principal modifications of the calyx and corolla, as well as many of the terms employed to designate them; which need not be here repeated.

505. The number of sepals that enter into the composition of a calyx is indicated by adjectives formed from the corresponding Greek numerals prefixed to the name; as, *disepalous*, for a calyx of two sepals; *trisepalous*, of three sepals; *tetrasepalous*, of four; *pentasepalous*, of five; *hexasepalous*, of six sepals; and so on. Very commonly, however, the Greek word for leaves, *phylla*, is used in

FIG. 447. Summit of the unexpanded corolla of *Datura meteloides*. 448. Transverse section of the same.

such composition; and the calyx is said to be *diphyllous*, *triphyllous*, *tetraphyllous*, *pentaphyllous*, *hexaphyllous*, &c., according as it is composed of two, three, four, five, or six leaves or sepals respectively. These terms imply that the leaves of the calyx are distinct, or nearly so. When they are united into a cup or tube, the calyx was by the earlier botanists incorrectly said to be *monophyllous* (literally one-leaved); — a term which we continue to use, guarding, however, against the erroneous idea which its etymology involves, and bearing in mind that the older technical language in botany is founded upon external appearance, and not the real structure, as we now understand it. The correct term, *calyx gamophyllous*, is now coming into use: this literally expresses the true state of the case, and is equivalent to the phrase *sepals united*; the degree of coalescence being indicated by adding “at the base,” “to the middle,” or “to the summit,” as the case may be. Still, in botanical descriptions, it is usual and ordinarily more convenient to regard the calyx as a whole, and to express the degree of union or separation by the same terms as those which designate the degree of division of the blade of a leaf (281–287): as, for example, *Calyx five-toothed*, when the sepals of a pentaphyllous calyx are united almost to the top; *five-cleft*, when united to about the middle; *five-parted*, when they are separate almost to the base; and *five-lobed*, for any degree of division less than five-parted, without reference to its particular extent.

506. The united portion of a gamophyllous calyx is called its *tube*; the distinct portions of the sepals are termed the *teeth*, *segments*, or *lobes*, according to their length as compared with the tube; and the orifice or summit of the tube is named the *throat*. The calyx is said to be *entire*, when the leaves of the calyx are so completely confluent that the margin is continuous and even. The terms *regular* and *irregular* (446, 471) are applied to the calyx or corolla separately, as well as to the whole flower. The counterpart term to calyx monophyllous or monosepalous, is *polyphyllous* or *polysepalous* (viz. of many leaves or sepals). This is equivalent to the phrase *sepals distinct*; and does not mean, as the etymology might lead one to suppose, that they are unusually numerous.

507. The Corolla has corresponding terms applied to its modifications. When its petals are distinct or unconnected, it is said to be *polypetalous*; when united, at least at the base, *monopetalous*, or more properly *gamopetalous*, as already explained. Various degrees of such union are shown in Fig. 450–460. The united por-

tions in the latter case form the *tube* of the corolla; the distinct parts are the *lobes*, *segments*, &c.; and the orifice is called the *throat*, just as in the calyx. The number of parts that compose the corolla is designated in the manner already mentioned for the calyx; viz. a corolla of two petals is *dipetalous*; of three, *tripetalous*; of four, *tetrapetalous*; of five, *pentapetalous*; of six, *hexapetalous*; of seven, *heptapetalous*; of eight, *octopetalous*; of nine, *enneapetalous*; of ten, *decapetalous*.

508. Frequently the petals (and rarely the sepals) taper into a stalk or narrow base, analogous to the petiole of a leaf, which is called the *claw* (*unguis*); and hence the petal is said to be *unguiculate*; as in Cruciferous flowers (Fig. 405), the Pink family (Fig. 432), and Gynandropsis (Fig. 433), &c.; the expanded portion, like that of the leaf, being distinguished by the name of the *lamina*, *limb*, or *blade*.



509. Some kinds of polypetalous flowers receive particular names from the form or arrangement of their floral envelopes, especially of the corolla. They may be divided into the regular and the irregular—terms which have already been defined (446, 471). Among the *regular* forms we may mention the *rosaceous* flower, like that of the Rose, Apple, &c., where the five spreading petals have no claws, or very short ones; the *liliaceous*, of which the Lily is the type, where the claws or base of the petals or sepals are erect, and gradually spread towards their summits; the *caryophyllaceous*, as in the Pink and its allies (Fig. 449), where the five petals have long and narrow

FIG. 449. Corolla of Soapwort, of five separate, long-clawed or *unguiculate* petals.

FIG. 450. Flower of Gilla or *Ipomopsis coronopifolia*; the parts answering to the claws of the petals of the last figure here all united into a tube.

FIG. 451. Flower of the Cypress-Vine; the petals a little farther united into a five-lobed spreading border.

FIG. 452. Flower of the small Scarlet Morning-Glory, the five petals it is composed of perfectly united into a trumpet-shaped tube, and a nearly entire spreading border.

claws, which are enclosed in the tube of the calyx; and the *cruciate*, or *cruciform*, which gives its name to the Mustard family, where the four unguiculate petals, diverging equally from one another, are necessarily disposed in the form of a cross, as in the Mustard (Fig. 405). Among the *irregular* polypetalous flowers, which are extremely varied in different families, the *papilionaceous* or *butterfly-shaped* corolla of the Pulse family is the most familiar, and has already been illustrated (471, Fig. 392).



510. Several forms of the gamopetalous corolla, or gamophyllous calyx, have been distinguished by particular names. These are likewise divided into the *regular*, where their parts are equal in size, or equally united; and the *irregular*, where their size or degree of union is unequal (471). Among the former are the *campanulate* or *bell-shaped*, as the corolla of the Harebell (Fig. 456), which enlarges gradually and regularly from the base to the summit;



the *infundibuliform*, or *funnel-shaped*, where the tube enlarges very gradually below, but expands widely at the summit, as in the corolla of Morning-Glory (Fig. 1035 and 452); *tubular*, where the form is somewhat cylindrical throughout, as in Trumpet Honeysuckle; *hypocrateriform* (more correctly *hypocraterimorphous*), or *salver-shaped*,

FIG. 453. Rotund or wheel-shaped and five-parted corolla of the Bittersweet (*Solanum Dulcamara*).

FIG. 454. Wheel-shaped and five-cleft corolla of the common Potato.

FIG. 455. The almost entire and open bell-shaped corolla of a Ground Cherry (*Physalis*).

FIG. 456. Campanulate corolla of the Harebell, *Campanula rotundifolia*. 457. Salver-shaped corolla of *Phlox*. 458. Labiate (ringent) corolla of *Lamium*; a side view. 459. Personate corolla of *Antirrhinum*. 460. Personate corolla of *Linaria*, spurred at the base.

where the limb spreads at right angles with the summit of the more or less elongated tube, as in the corolla of Cypress-Vine (Fig. 451) and Phlox (Fig. 457); and *rotate*, or *wheel-shaped*, when a hypocrateriform corolla has a very short tube, as in the Forget-me-not, Bittersweet (Fig. 453), and Potato (Fig. 454).

511. The principal irregular gamopetalous or gamophyllous forms that have received a separate appellation are the *ligulate* or *strap-shaped*, which has already been explained (473), and the *labiate* or *bilabiate*. The latter, as already stated, is produced by the unequal union of the sepals or petals (473), so as to form an upper and a lower part, or two lips, as they are called, from an obvious resemblance to the open mouth of an animal (Fig. 458–460). This variety is almost universally exhibited by the corolla of the Sage or Mint family (which is therefore called *Labiatae*), as well as of several related families; and the calyx is frequently bilabiate also, as in the Sage. And since, in the corolla of these families, two of the five petals enter into the composition of the upper lip, and three into that of the lower, this is necessarily inverted in the bilabiate calyx, three of the sepals combining to form the upper lip, and two to form the lower.

512. When the upper lip is arched, as in the corolla of *Lamium* (Fig. 458), it is sometimes called the *galea*, or *helmet*. When the two lips are thus gaping and the throat open, the corolla is said to be *ringent*. When the mouth is closed, or partly so, by an elevated portion or protuberance of the lower lip, called the *palate*, as in the Snapdragon and Toadflax (Fig. 459, 460), the corolla is said to be *personate*, or *masked*.

513. In the Snapdragon, the base of the corolla is somewhat protuberant, or *saccate*, on the anterior side; in the Toadflax, the protuberance is extended into a hollow *spur*. A projection of this kind is not uncommon, in various families of plants. One petal of the Violet is thus *spurred* or *calcarate* (Fig. 397); so is one of the outer petals in the Fumitory, and each of them in *Dicentra* (Fig. 370). So, also, one of the sepals is spurred or strongly sac-shaped in the Jewelweed (*Impatiens*), and the Larkspur (Fig. 398); and all five petals take this shape in the Columbine. A monster of the Toadflax is occasionally found, in which the four remaining petals of the five which enter into its composition, affect the same irregularity, and so bring back the flower to a singular abnormal state of *regularity*. This was called by Linnaeus *Peloria*; a name which is now used to designate the same sort of monstrosity in different flowers.

514. The petals are sometimes furnished with appendages on their inner surface, such as the *crown* at the summit of the claw in *Silene* (Fig. 378, 449), and the scales similarly situated on the gamopetalous corolla of the Comfrey, &c. These appendages sometimes represent a circle of sterile and metamorphosed stamens; but more commonly they seem really to belong to the petal.

515. As to duration, sometimes the floral envelopes are *caducous*, i.e. falling off when the blossom opens, as the calyx in the Poppy family and the corolla of the Grape-Vine (Fig. 384). More commonly they are *deciduous*, or fall after expansion, but before the fruit forms. When they remain until the fruit is formed or matured, they are *persistent*, which is often the case with the calyx, especially when it has a green color and foliaceous texture. When they persist in a dry or withering state, as the corolla of Heaths, Campanula, &c., they are said to be *marcescent*.

516. Besides serving as organs of protection, the sepals, when green, assimilate sap, and act upon the air like ordinary foliage (344, 345). The petals, like other uncolored (that is greenless) parts, do not evolve oxygen, but abstract it from the air, and give off carbonic acid; in other words, they decompose assimilated matter,—a process which appears to be needful in flowering, and to subserve some important end at the time (368–373). The tissue of a petal is much the same as that of a leaf, except that it is much more delicate and the fibro-vascular system is generally reduced to slender bundles of a few spiral vessels, &c., which form its veins.

SECT. VI. THE STAMENS.

517. The Stamens have already been considered in a general way (418). Before describing their structure more particularly, the principal terms which relate to their number, connection, and position may be mentioned. Most of these terms were devised by Linnæus as names of the classes of his Artificial System of classification (Part II. Chap. IV.), founded mainly upon characters furnished by the stamens. Their number in a flower is accordingly expressed by the names of the eleven or twelve earlier Linnæan classes (990), put into adjective form. Thus, a flower with one stamen is said to be *monandrous*; with two, *diandrous*; with three, *triandrous*; with four, *tetrandrous*; with five, *pentandrous*; with six, *hexandrous*;

with seven, *heptandrous*; with eight, *octandrous*; with nine, *enneandrous*; with ten, *decandrous*; with twelve, *dodecandrous*. When more than twelve, and inserted on the calyx, they are *isocandrous*, or, when inserted on the receptacle, *polyandrous*.

518. As to their union with each other, this may take place in various ways. Sometimes the filaments are combined, while the anthers are distinct. When thus united by their filaments into one set, they are said to be *monadelphous*; as in the Lupine, &c. (Fig.

462) and Mallow. When united by their filaments into two sets, they are *diadelphous*, as in most plants of the Pulse family, where nine stamens form one set and the tenth is solitary (Fig. 461); and

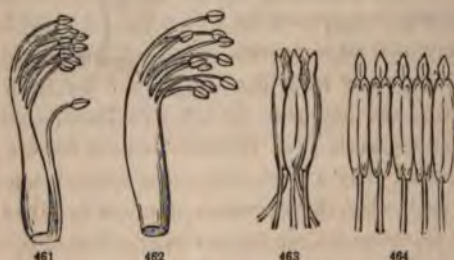
in *Dicentra* (Fig. 369–371), where the six stamens are equally combined in two sets. When united or arranged in three sets or parcels, they are said to be *triadelphous*, as in the common St. Johnswort; or if in several, *polyadelphous*; as in Linden. When stamens are united by their anthers into a tube or ring, they are said to be *syngenesious* (Fig. 463, 464). This occurs in the whole vast order of *Compositæ*. Here the five filaments are distinct; whereas in *Lobelia*, and also in the Melon and Gourd (Fig. 465, 466), both the filaments and the anthers are united; that is, the stamens are *monadelphous* as well as *syngenesious*.

519. As to insertion, stamens are *hypogynous* (466) when borne on the receptacle, that is, when not adnate to any other organ:

FIG. 461. Diadelphous stamens (9 and 1) of a Pea. 462. Monadelphous stamens of a Lupine.

FIG. 463. Five syngenesious stamens of a *Composita*. 464. The same, laid open.

FIG. 465. Column of stamens, at once triadelphous and syngenesious, of the Gourd: the floral envelopes cut away. 466. A cross-section of the united anthers, nearly the natural size. 467. A sinuous anther of the Melon.



perigynous (467) when borne on or adnate to any part of the calyx; *epipetalous*, when borne on the corolla, as in the greater number of monopetalous flowers; and *epigynous* (469), when borne on the ovary. In some cases the adnation proceeds further, and the stamens are inserted on, i. e. are consolidated with, the style, as in the *Orchis* family; then they are said to be *gynandrous* (Fig. 468).

520. There are two cases in which inequality in the length of the filaments is expressed by a technical term. Namely, the stamens are said to be *didynamous* when, being only four in number, they are in pairs, and one pair is longer than the other; as in *Gerardia* (Fig. 407), and in most flowers with a bilabiate corolla. And they are *tetradynamous* when, being six in number, two are shorter than the remaining four, as in Mustard and all that family of plants with Cruciferous flowers (Fig. 406).

521. A stamen consists of its *filament* and its *anther* (418). The filament, being a mere stalk or support of the anther, is not an essential part; it is to the anther what the petiole is to the blade of a leaf. Sometimes, therefore, it is wanting, when the anther is *sessile*. The anther is essential to a perfect stamen. But sometimes a stamen, or what stands in the place of one, is destitute of an anther, i. e. is *sterile*, as in Fig. 408; and also the upper one in Fig. 468, *st.*, which is a sterile filament enlarged into a petal-like body. The true nature of the organ is known by its position.

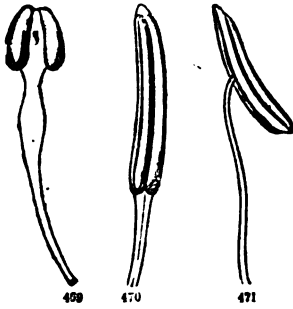
522. The *Filament*, although usually slender and stalk-like, assumes a great variety of forms: it is sometimes dilated so as to resemble a petal, except by its bearing an anther; as in the transition states between the true petals and stamens of the Water-Lily (Fig. 344). The filament is anatomically composed of a central bundle of spiral vessels or ducts, which represent the fibro-vascular system of the leaf, in the same state as in the petiole, enveloped by parenchyma; the outer stratum of which forms a delicate epidermis.

523. The *Anther*, which is the essential part of the stamen, is usually borne on the apex of the filament; and commonly consists of two *lobes*, or *cells* (*thecae*), placed side by side, and connected by a prolongation of the filament, called the *connectivum*, or *connective*.



FIG. 468. Stamens and style of a *Cyripedium*, united into one body or *column*: *a, a*, anthers: *st.* a sterile stamen: *stig.* the stigma.

524. The attachment of the anther to the filament presents three principal modes. 1st. When the base of the connective exactly corresponds with the apex of the filament and with the axis of the anther, the latter is termed *innate*, and rests firmly upon the summit



of the filament, as in Fig. 469. 2d. When the lobes of the anther adhere for their whole length to a prolongation of the filament, or to a broad connective (whichever it be called), so as to appear lateral, it is said to be *adnate*; as in Magnolia, Liriodendron (Fig. 470), &c. Here the anther must be either *extrorse* or *introrse*. It is *introrse*, or *turned inwards*, when it occupies the inner

side of the connective, and faces the pistils, as in Magnolia; but when the anther looks away from the pistils and towards the petals or sepals, it is said to be *extrorse*, or *turned outwards*, as in Iris, Liriodendron, and Asarum (Fig. 472). 3d. When the anther is fixed by a point near its middle to the apex of the filament, on which it lightly swings, it is said to be *versatile*; as in all Grasses, in the Lily, and in the Evening Primrose (Fig. 471), &c. In this case, as in the preceding, the anther is said to be *introrse*, or *incumbent*, when it is turned towards the pistil, which is the most common way; and *extrorse*, when it faces outwards.

525. The *connective* is often inconspicuous or wholly wanting, so that the lobes of the anther are directly in contact on the apex of the filament; but it is commonly evident. It is often produced into an appendage at the tip of the anther, as in Magnolia and Liriodendron (Fig. 470), the Papaw (Fig. 956, where it forms a rounded top), and Asarum (Fig. 472). Appendages or processes from the back of the connective are seen in the stamens of the Violet and of many Ericaceous plants.



526. Each of the two cells or lobes of the anther is marked with a lateral line or furrow, running from top to bottom; this is the

FIG. 469. A stamen of *Isopyrum bitematum*, with an innate anther. 470. Stamen of Liriodendron, or Tulip-tree, with an adnate extrorse anther. 471. Stamen of *Oenothera glauca*, with the anther fixed by its middle and versatile.

FIG. 472. A stamen of *Asarum Canadense*, with an adnate anther.

suture, or *line of dehiscence*, by which the anther opens at maturity to discharge the pollen (Fig. 473). This line is for the most part exactly lateral in innate anthers; but it looks more or less evidently, and often directly, inward in introrse, and outward in extrorse anthers. In certain cases the cells of the anther open only at the summit, by a pore or hole, as in *Pyrola* (Fig. 474) and most *Ericaceous* plants. In the *Whortleberry* family each cell or lobe is commonly prolonged into a tube, which opens only at the apex (Fig. 391). In the *Barberry* (Fig. 475), and in nearly all plants of the *Barberry* family, the whole face of each anther-cell separates by a continuous line, forming a kind of door, which is attached at the top, and turns back, as if on a hinge: in this case the anthers are said to open by valves. In the *Sassafras* (Fig. 1114), and many other plants of the *Laurel* family, each lobe of the anther opens by two such valves, like trap-doors.



527. Sometimes the anthers are one-celled by the suppression of one lobe, being *dimidiate*, or reduced as it were to half-stamens; as in *Gomphrena* or *Globe-Amaranth* (Fig. 478).



But most one-celled anthers are the result of the *confluence* of the two cells into one. A comparison of the two-celled anther of *Pentstemon pubescens*, where the two cells diverge below and are somewhat united at the top (Fig. 476) with the kidney-shaped one-celled anther of a *Mallow*, opening by a continuous line all round the margin (Fig. 477), shows how this result is brought about.

528. As to anatomical structure, each lobe of the full-grown anther consists of an epidermal membrane, lined with a delicate fibrous tissue, and surrounding a cavity filled with pollen. This

FIG. 473. A stamen, with its anther, *b*, opening in the normal manner down the whole length of the outer side of each cell: *a*, the filament.

FIG. 474. Stamen of a *Pyrola*; each cell of the anther opening by a terminal orifice.

FIG. 475. Stamen of a *Barberry*; the cells of the anther opening by an upflitted valve.

FIG. 476. A stamen of *Pentstemon pubescens*; anther-cells slightly confluent.

FIG. 477. Stamen of *Mallow*; the two cells confluent into one, opening round the margin.

FIG. 478. Anther of *Globe Amaranth*, of only one cell; the other cell obliterated.

fibrous lining (a little of which is shown in Fig. 45, from the anther of *Cobaea*) is composed of simple or branching threads or bands, which formed the thickening deposit on the walls of large parenchymatous cells; all the membrane between the bands becoming obliterated as the anther approaches maturity, the latter alone remains as a set of delicate fibres. This fibrous layer gradually diminishes in thickness as it approaches the line of dehiscence of the cell, and there it is completely interrupted. These very elastic and hygroscopic threads lengthen or contract in different ways, according as the anther is dry or moist, and are thought to favor the egression of the pollen. The outer stratum of the wall of the anther in drying contracts more than the inner, and so opens the cell, in many cases turning the walls inside out after dehiscence, as in *Lilium* and *Grasses*.

529. Of all the floral organs, the anther shows least likeness to a leaf. Nevertheless, the early development is nearly the same. Like the leaf, the apex is earliest formed, appearing first as a solitary protuberance, and the anther is completed before the filament, which answers to the leafstalk, makes its appearance. At first, the anther is of a greenish hue, although at maturity the cells assume a different color, more commonly yellow. A transverse section of the forming anther shows four places in which the transformation of the parenchyma into pollen commences, which answer to the centre of the four divisions of the parenchyma of a leaf, viz. the two sides of the blade, each distinguished into its upper and its lower stratum. So



that the anther is primarily and typically four-celled, each lobe being divided by a portion of untransformed tissue, stretching from the connective to the opposite side, which corresponds to the margin of the leaf and the line of dehiscence. This appearance is presented by a large number of full-grown anthers: but the partition usually disappears before the anther opens, when each lobe becomes single celled. The normal anther is consequently considered as two-celled. In *Menispermum* and *Cocculus*, however, the anther is strongly four-lobed externally, and each lobe forms a distinct cell at maturity.

530. Viewed morphologically, therefore, the filament answers to

FIG. 479. Plan of a stamen as answering to a leaf; the upper part of the anther cut away and the summit of a leaf represented above it.

the petiole of a leaf; the anther, to the blade. The connective represents the midrib; the lobes or cells of the anther represent the two symmetrical halves of the blade; and the line of dehiscence is normally along the margins of the transformed leaf. What in the leaf would be cells of parenchyma develop as

531. Pollen. This usually powdery substance consists of grains, of definite size and shape, uniform in the same plant, but often very different in different species or families. The grains are commonly single cells, globular or oval in shape, and of a yellow color. But in Spiderwort they are oblong; in the Cichory and Thistle tribes many-sided (Fig. 485); in the Musk-plant spirally grooved (Fig. 480); in the Mallow family (Fig. 483) and the Squash and Pump-



kin, beset with bristly projections, &c. The pollen of Pine (Fig. 486), as well as that of the Onagraceæ (Fig. 487, 489), is not so simple, but appears to consist of three or four blended cells; that of all true Ericaceæ evidently consists of four grains or cells united



(Fig. 488). The most extraordinary shape is that of *Zostera*, or the Eel-grass of salt-water, in which the grains (destitute of the outer coat) consist of long and slender threads, which, as they lie side by side in the anther, resemble a skein of silk.

532. Pollen-grains are usually formed in fours, by the division of the living contents of mother cells first into two, and these again into two parts, which, acquiring a coat of cellulose, become specialized cells (36). As the pollen completes its growth, the walls of the mother cells are usually obliterated. But sometimes the enclosing cells persist, and collect the



FIG. 480-489. Forms of pollen: 480, from *Mimulus moschatus*; 481, *Sicyos*; 482, *Echinocrystis*; 483, *Hibiscus*; 484, *Lily*; 485, *Cichory*; 486, *Pine*; 487, *Circeæ*; 488, *Kalmia*; 489, *Evening Primrose*.

pollen-grains into coherent masses of various consistence, as is remarkably the case in the Orchis and Milkweed families (Fig. 543, &c.). Such *pollen-masses* are sometimes termed *pollinia*.

533. The threads, resembling cobweb, that are loosely mixed with the pollen of the Evening Primrose, are the vestiges of obliterated mother cells.

534. Pollen-grains have two coats. The outer coat, called the *ectine*, is comparatively thick, and often granular or fleshy. This is later formed than the inner, and by a kind of secretion from it: to all the markings belong. The inner coat, or *intine*, which is the proper cell-membrane, is a very thin and delicate, transparent and colorless membrane, of considerable strength for its thickness. The pollen of *Zostera* and of some other aquatic plants is destitute of the outer coat (531).

535. The cavity enclosed by the coats is filled with a viscid liquid, rich in protoplasm, which often appears slightly turbid under the higher powers of ordinary microscopes, and, when submitted to a magnifying power of about three hundred diameters, is found to contain a multitude of minute particles (*forillæ*), the larger of which are from the four-thousandth to the five-thousandth of an inch in length, and the smaller only one fourth or one sixth of this size. The smaller exhibit the constant molecular motion of all such minute particles when suspended in a liquid and viewed under sufficient magnifying power. When wetted, the grains of pollen promptly absorb water by endosmosis (37), and are distended, changing their shape somewhat, and obliterating the longitudinal folds, one or more in number, which many grains exhibit in the dry state. Soon the more extensible and elastic inner coat inclines to force its way through the weaker parts of the outer, especially at one or more thin points or pores; sometimes forming a projection of considerable length, when the absorption is slow and the exterior coating tough. If the absorption continues, the distention soon overcomes the resistance of the elastic inner coat, which bursts, and the contents are discharged.

536. When fresh, living pollen falls upon the stigma, however, which is barely moist, it does not burst, but the inner membrane is slowly projected, often through particular points, clefts, or openings of the outer coat, in the form of an attenuated transparent tube (Fig. 537-547), filled with its fluid contents, and which penetrates the naked and loose cellular tissue of the stigma, and buries itself in

the style. This is not a mechanical protrusion, but a true growth, the materials for which are supplied by nourishment imbibed from the stigma and style. Its further course and the office it subserves will be considered after the structure of the pistil is made known. (Sect. IX.)

SECT. VII. THE PISTILS.

537. The Pistils (419) occupy the centre of the flower, and terminate the axis of growth. Linnaeus established the orders of his Artificial System mainly upon the pistils, and this introduced a series of terms expressive of their number in a flower, analogous to those used for the number of stamens (517). Thus a flower with a single pistil is said to be *monogynous*; with two, *digynous*; with three, *trigynous*; with four, *tetragynous*; with five, *pentagynous*; and so on: when more numerous or indefinite, the flower is *polygynous*.

538. It is comparatively seldom that the pistils are exactly equal to the petals or sepals in number; they are sometimes more numerous, and arranged in several rows upon the enlarged or prolonged receptacle, as in the Magnolia, the Strawberry, &c., and perhaps more frequently they are reduced to less than the symmetrical number, or to a single one. Yet often what appears to be a single pistil is not so in reality, but a compound organ, formed by the union of two, three, or a greater number of simple pistils; these organs being subject to coalescence in the same way as the stamens (518) and the petals (507, 462).

539. A simple and complete pistil, as already described (420), is composed of three parts: the OVARY, or seed-bearing portion; the STYLE, or tapering portion, into which the apex of the ovary is prolonged; and the STIGMA, usually situated at the summit of the style, consisting of a part, or sometimes a mere point, of the latter, divested of epidermis, with its moist cellular tissue exposed to the air. The ovary, which contains the ovules, or bodies which are to become seeds, is of course a necessary part of the pistil; the stigma, which receives from the anthers the pollen (531) by which the ovules are fertilized, is no less necessary; but the intervening style is no more essential to the pistil than the filament is to the stamen, and is therefore not uncommonly wanting. In the latter case, the stigma is insituate upon the apex of the ovary. In Tasmania it actually occupies the side of the ovary for nearly its whole length, and is sepa-

rated from the line to which the ovules are attached only by the thickness of the walls: it is nearly the same in our *Schizandra* (Fig. 493), another plant of the *Magnolia* family. The style sometimes proceeds from the side, or even from near the apparent base of the ovary; as in the Strawberry (Fig. 428).

540. When the pistil is single, or when several coalesce into one, it will necessarily terminate the axis, and appear to be a direct continuation of it. When there are two pistils in the flower, they always stand opposite each other (so that if they coalesce it is by their inner faces); and are either *lateral* as respects the flower, that is, one on the right side and the other on the left, in a plane at right angles to the bract and axis (444), as in the Mustard family, the Gentian family, and a few others; or, more commonly, *anterior and posterior*, one before the axis and the other before the bract of the axillary flower. When they accord in number with the sepals or petals, they are either opposed to or alternate with them; and the two positions in this respect are sometimes found in nearly related genera, so as to baffle our attempts at explaining the cause of the difference. In *Pavonia*, for example, the five pistils are opposite the petals; in *Malvaviscus* and *Hibiscus*, alternate with them. In *Sida* (when five) they stand opposite the petals; in *Abutilon*, opposite the sepals.

541. Pistils occur under such a diversity of forms, and exhibit such various complications, that the plan of their structure and the distinction between simple and compound pistils require to be well understood. Commencing, therefore, with the most natural forms, and proceeding gradually to the more complex or disguised, we first consider

542. *The Simple Pistil*, and the way in which it answers to a leaf. A simple pistil answers to a single leaf. A compound pistil answers to two or more leaves combined, just as a monopetalous corolla answers to two or more petals, or leaves of the flower, united into one body. As to its morphology, the botanist regards a simple pistil as consisting of the blade of a leaf, curved inwards until its margins meet and unite, forming in this way a closed case, or pod, which is the ovary. So that the upper face of the altered leaf answers to the inner surface of the ovary, and the lower, to its outer surface. And the ovules are borne on what answers to the united edges of the leaf. The tapering summit, rolled together and prolonged, forms the style, when there is any; and the edges

of the altered leaf turned outwards, either at the tip or along the inner side of the style, form the stigma. This will be clearly understood on comparing Fig. 342 and Fig. 491, which are pistils transversely divided, with Fig. 490, a leaf curved inwards until its margins nearly meet, and with Fig. 492, a simple pistil of *Caltha* or Marsh-Marigold which has matured, split open along the inner side to discharge the seeds it bore, and spread out into the shape of a leaf.

543. The line formed by the union of the margins of the leaf is called the *Inner or Ventral Suture*, and always looks towards the axis of the flower. This is a true suture, or *seam*, as the word denotes. The opposite line, answering to the midrib, is sometimes apparent as a thickened line, and is termed the *Outer or Dorsal Suture*. The ovules or young seeds are borne (in all ordinary cases at least) on the inner suture, or some part of it; that is, on what answers to the united margins of the infolded and transformed leaf. The part in the cell of the ovary to which the ovules are attached, and which is commonly more or less enlarged or projecting when the ovules are numerous, is named

544. The *Placenta*. As this corresponds with the ventral suture, and is in fact a part of it, or a cellular growth from it, it always belongs next the axis of the flower; as is evidently the case when two, three, or more pistils are present. Each placenta necessarily consists of two parts, one belonging to each margin of the transformed leaf. It therefore is frequently two-lobed, or of two diverging lamellæ (Fig. 342). This shows why the ovules are apt to occupy two longitudinal rows, as in



FIG. 490. A leaf infolded, to illustrate the theory of the formation of the pistil.

FIG. 491. Pistil of *Isopyrum biternatum*, cut across; the inner or ovule-bearing side turned towards the observer.

FIG. 492. Ripe pistil of *Caltha palustris*, after opening and discharging the seeds.

FIG. 493. Vertical section of a pistil of *Schizandra coccinea*; a side view. 494. Pistil of *Hydrastis*. 495. Pistil of *Actaea rubra*, cut across, so as to show the interior of the ovary (ventral suture turned towards the observer).

the figure last cited, and in Fig. 491, 495, &c., one row belonging to each margin of the leaf. A simple pistil, accordingly, can have only one placenta; but that is structurally double.

545. So a single pistil can have only one style and one stigma. But as the stigma answers to the margins of the apex of the leaf, this must also be double in its nature. And this is evidently the case in the Peony and Isopyrum (Fig. 491), in the Tulip, as well as in Fig. 493 – 495, and in almost all cases in which the stigma extends down the inner face of the style, as it frequently does. Such unilateral stigmas we accordingly take to be the typical form; and say that, while the united margins of the transformed leaf which compose the ventral suture are *turned inwards into the cell of the ovary to bear the ovules, in the simple style they are exposed externally to form the stigma*. Where the stigma is terminal, or occupies only the apex of the style, we suppose that these margins are in-folded in the style also, and form in its interior the loose conducting tissue through which a communication is established between the stigma and the interior of the ovary.

546. The ovary of a simple pistil obviously can have but one cavity or cell; except from some condition out of the natural order of things. But the converse does not hold true: all pistils of a single cell are not simple. Many compound pistils are one-celled, as will presently be explained.

547. A leaf or member of the gynæcium then, when separate, forms a simple pistil; when combined with others, it makes part of a compound pistil. It is convenient to have a name which shall designate a single pistil-leaf, whether occurring as a distinct simple pistil, or as an element of a compound pistil. For this purpose the name of CARPEL has been devised. A carpel is either a simple pistil, or is one of a circle of leaves which compose a compound pistil. When the pistils are distinct from each other, they are said to be *apocarpous*; when united into one body, *syncarpous*. This union produces a

548. Compound Pistil. All degrees of union of the carpels may be observed, from the coalescence of the lower part of their ovaries, their summits remaining separate (as in Fig. 496), or from the complete union of the ovaries into one body, the styles remaining separate (as in Fig. 497), to the complete coalescence of the styles also (Fig. 498), and even of the stigmas (Fig. 499), into one body. It is evidently the same as if two or more pistils (in Fig. 497 – 499, three

pistils) were pressed together as they grew and consolidated more or less completely into one. And in this, the most normal case, we have as the result compound pistils

549. With two or more Cells and Axile Placentæ. For it is evident



that, if the contiguous parts of a whorl of three or more closed carpels cohere, the resulting compound ovary will have as many cavities, or cells, as there are carpels in its composition, and the placenta (one in the inner angle of each carpel) will all be brought together in the axis of the compound pistil. And the partitions, or *Dissepiments*, which divide the compound ovary into cells, manifestly consist of the united contiguous portions of the walls of the carpels. These necessarily are composed of two layers, one belonging to each carpel; and in ripe pods they often split into the two layers. True dissepiments must always be equal in number to the carpels of which the compound pistil is composed.

550. In certain cases, indeed, there are additional partitions, or *false dissepiments*. These are commonly projec-



FIG. 496. Pistil of a Saxifrage, composed of two carpels or simple pistils united below, but distinct above; cut across both above and below.

FIG. 497. Pistil of common St. Johnswort, of three united ovaries; their styles distinct.

FIG. 498. The same of another species of St. Johnswort (*Hypericum prolificum*), the styles also united into one, which, however, split apart in the fruit.

FIG. 499. Pistil of Tradescantia or Spiderwort, even the three stigmas united into one. The ovary is all cut across to show the internal structure.

FIG. 500. Cross-section of a flower of Flax; each of the five cells of the ovary partly divided by an imperfect false partition from the back.

tions or growths from the dorsal suture ; whether in a simple pistil (as that of most species of *Astragalus*, Fig. 805), or from the back of each proper cell of a compound pistil, as in the Service-berry, the Blueberry, and the common Flax (Fig. 500).

551. We have considered only the case of compound pistils of two or more cells in the ovary. But compound pistils also not unfrequently occur

552. With only one Cell. And of these there are two kinds to be noticed, those with *axile*, and those with *parietal placenta*. That is, in the first, the ovules are borne in the axis or centre of the ovary, either at the base or on a column which occupies the centre ; in the second, they are borne on some part of the parietes or walls of the ovary. The first, viz.

553. With a Free Central Placenta, is found in the Primrose, Purslane (Fig. 389), and Pink families (Fig. 432, 501, 502).



In the Pink family this evidently results from the obliteration of the dissepiments (as many as there are styles or stigmas) ; and vestiges of these may be detected at an early stage, and sometimes at the base of the full-grown ovary ; while certain plants of the same family, of otherwise identical structure, retain the partitions even in the ripe pod. In other instances, as in *Dionæa*, *Thrift*, &c., this is doubtless a modification of parietal placentation, with ovules produced only at the bottom. This brings us to the case of compound one-celled-pistils

554. With Parietal Placentæ, that is, with the placenta borne on the sides or parietes of the ovary, as in the Poppy, Caper, Cistus or Rock-Rose (Fig. 507), Violet, Sundew (Fig. 510), and Currant families, and many others. To comprehend this per-



FIG. 501. Vertical section through the compound tricarpeillary ovary of a plant of *Spergularia rubra*, showing the free central placenta. 502. Transverse section of the same.

FIG. 503-506. Diagrams illustrating parietal and free central placentation. 503. Cross-section of a tricarpeillary ovary, with a free central placenta, produced by the obliteration of the dissepiments. 504. Section of an ovary with three strictly parietal placentas. 505. Same, except that there are incomplete partitions.

fectly, we have only to imagine two, three, or any number of pistil-leaves (like Fig. 490), arranged in a circle, to unite with one another by their contiguous edges, either without any introflexion or infolding at all (Fig. 504), or at least without their infolded edges having reached the centre and united there (Fig. 505, 506). The combination is accordingly much like that by which petals unite to form a monopetalous corolla, only the edges of the pistil-leaves are always turned in, where they

bear the ovules. Such an ovary may well be compared with the valvate unopened calyx of *Clematis*, the margins of the sepals more or less turned inwards (Fig. 445). Every gradation is found between axile and parietal placentation, especially in the St. Johnswort family (Fig. 508, 509) and in the Gourd family.

555. An ovary with parietal placentæ is necessarily one-celled; except it be divided by an anomalous partition, such as is found in Cruciferous plants, and in the Trumpet Creeper.

556. It will be seen that parietal placentæ are necessarily double, like the placenta of a simple ovary, or of each carpel of a compound several-celled ovary; but with this difference,

that in these the two portions belong to the two margins of the same carpel; while in parietal placentæ they are formed from the coalescent margins of two adjacent carpels.

557. The number of carpels of which a compound ovary consists is indicated by the number of true dissepiments when these exist; or by the number of placentæ, when these are parietal; or by the number of styles or stigmas, when these are not wholly united into one body. Thus a simple pistil has a single cell, a single placenta,



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FIG. 506. Plan of a one-celled ovary with three parietal placentæ, cut across below; the upper part showing the top of the three leaves it is composed of, approaching, but not united.

FIG. 507. Ovary of *Helianthemum Canadense*, cut across, showing the ovules on three parietal placentæ.

FIG. 508. Transverse section of the ovary of *Hypericum graveolens*; the three large placentæ meeting in the centre, but not cohering. 509. Similar section of a ripe pod of the same; the placentæ now evidently parietal.

and a single style. A pistil of two carpels may be two-celled, with two placentæ, two styles, or two stigmas, &c.*

* There are, however, some exceptions which qualify these statements : —

1. Each placenta being a double organ (556), it occasionally happens that the two portions are separated more or less, as in Orobanchaceous plants, where a dicarpellary ovary appears on this account to have four parietal placentæ ; either approximate in pairs (as in our Cancer-root, *Conopholis*), or equidistant (as in *Aphyllon*).

2. Analogous to this is the case where the two constituent elements of the stigma (the only essential part of the style) separate into two half-stigmas, as is partially seen in Fig. 494, 495. The stigma, no less than the placenta, belongs to the margins of the infolded leaf (545), these margins being *ovuliferous* in the ovary and *stigmatiferous* in the style ; as Mr. Brown, the most profound botanist of this or any age, has clearly shown. These two constituent portions of the style or stigma occasionally separate, either entirely or in part, as in Euphorbiaceous plants, in Grasses, and especially in *Drosera* (Fig. 510), where there are consequently twice as many nearly distinct styles as there are parietal placentæ in the compound ovary. If the two component parts of the style of each carpel were reunited into one, in the usual manner, their number would equal the placentæ, and their position would be alternate with the latter. But since, in parietal placentation, each *half-placenta* is confluent (not with its fellow of the same

carpel, but) with the contiguous *half-placenta* of the adjacent carpel, it were surely no greater anomaly for the elements of such *half-stigmas* as those of *Drosera* to follow the same course. This is precisely what takes place in *Parnassia*, and in other cases where the stigmas are opposite the parietal placentæ ; — cases which were thought to be very anomalous, merely on account of the adoption of a false principle (that of the necessary alternation of the stigmas and placentæ), but which are really no more extraordinary than parietal placentation itself

3. Furthermore, the production of ovules is not always restricted to what answers to the margins of the carpellary leaves. In the Poppy, the whole surface of the long, imperfect partitions is covered with ovules ; in *Butomus*, they are borne over the whole internal face of each carpel, and in Water-Lilies over the whole surface, except the inner angle of each cell, where alone they normally belong. Reduced to two in the allied Water-Shield (*Brasenia*, Fig. 684), the ovules grow from the *dorsal suture*, or the midrib of the carpellary leaf alone ! And in the allied *Cabomba* itself we usually find its three ovules, one on the dorsal and one on the ventral suture, and the third on some variable part of the face of the cell in the vicinity of either suture. In *Obolaria*, *Bartonia* (*Centaurella*, *Michx.*), and in several species of *Gentian*, a compound one-celled ovary is ovuliferous over the whole face of the cell !

All placentation is very differently explained by those who adopt the hypoth-

FIG. 510. Pistil of *Drosera filiformis*, with three deeply two-parted styles : the ovary cut across, showing three parietal placentæ.



558. When the styles are separate towards the summit, but united below, they are usually described as a single organ; which is said to be *parted, cleft, lobed, &c.*, according to the extent of cohesion. This language was adopted, as in the case of leaves (281) and floral envelopes (462), long before the real structure was under-

esis of Schleiden, Endlicher, and others. According to this new view, since buds regularly arise from the axils of leaves and from the extremity of the stem or axis, and only in some exceptional and abnormal cases from the margins or surface of leaves, so ovules, which are viewed as a form of buds, are considered to arise from the receptacle, either from the axis of the flower, like terminal buds, or from the axils of the carpellary leaves, like axillary buds. Thus, placentæ are supposed to belong to the stem, and not to the carpellary leaves; and a one-celled ovary, with one or more ovules arising from the base of the cell, would nearly represent the typical state of the gynæcium. This theory, which the intelligent student may easily apply in detail, offers a ready explanation of free central placentation, especially in such cases as *Primula*, &c., where not a trace of dissepiments is ever discoverable. But in *Caryophyllaceæ* the dissepiments are often manifest. In applying it to ordinary central placentation, we have to suppose the cohesion of the inflexed margins of the carpellary leaves with a central prolongation of the axis or receptacle which bears the placentæ. But in parietal placentation, the advocates of this theory are driven to the violent supposition that the axis divides within the compound ovary into twice as many branches as the carpels in its composition, and that these branches regularly adhere, in pairs, one to each margin of all the carpellary leaves. Its application is attended with still greater difficulties in the case of simple and uncombined pistils, where the ovules occupy the whole inner suture, which must be taken as the typical state of the gynæcium; but to which the new hypothesis can be adapted only by supposing that an ovuliferous branch of the axis enters each carpel, and separates into two parts, one cohering with each margin of the metamorphosed leaf. This view, however, not only appears absurd, but may be disproved by direct observation, as it has been most completely by those monstrosities in which an anther is changed into a pistil, or even one part of the anther is thus transformed and bears ovules, while the other, as well as the filament, remains unchanged; — a case where the ovules are far removed from anything which can possibly belong to the axis. We may further remark, that even the appearance of a placenta or ovuliferous body in the apparent axil of a carpellary leaf no more proves that the body in question belongs to the axis, than that the appendage before the petals of *Parnassia* and the American *Linden* represents a branch instead of a leaf. As to the terminal naked ovule of the *Yew*, where the structure, on any view, is reduced to the greatest possible simplicity, it is surely as probable that it answers to the earliest formed, or *foliar*, portion of the ultimate phyton, here alone developed, as to the *cauline* part, which so seldom appears in the flower. The most important of these points are elucidated by Mr. Brown, in *Plantæ Javanicæ Rariores*, pp. 107 - 112, in two notes, which apparently are not sufficiently anists.

stood: but, as it involves an erroneous idea, the expressions, *Styles distinct; united at the base; united to the middle, or summit, &c.*, as the case may be, should be employed in preference.

559. A few casual exceptions occur to the general rule that ovules and seeds are both produced and matured within an ovary, namely, in a closed carpellary leaf or set of combined carpellary leaves. In the Blue Cohosh (*Caulophyllum thalictroides*) the ovules rupture the ovary soon after flowering, and the seeds become naked; and in Mignonette they are imperfectly enclosed, the ovary being open at the summit from an early period. In all such cases, however, the pistil is formed and the ovules are fertilized in the ordinary way.

560. Gynæcium of Gymnosperms Plants. A far more remarkable exception is presented by two natural families, viz. Coniferae (Pines,

Firs, &c.) and Cycadaceae (Cycas, Zamia). Here the pistil, as likewise the whole flower, is reduced to the last degree of simplicity; each fertile flower con-

sisting merely of an open carpellary leaf, in place of an ordinary pistil, in the form of a scale (Fig. 511 - 513, 515, 516), or of some other shape, and bearing two or more ovules upon some part of its upper surface. At the time of blossoming, these pistil-leaves of the forming cone diverge, and the pollen, abundantly shed from the staminate blossoms, falls directly upon the exposed ovules. Afterwards the scales close over each other until the seeds are ripe. In the Yew there is no carpel or pistil-leaf at all; but the fertile blossom consists of a solitary naked ovule, borne on the extremity of a

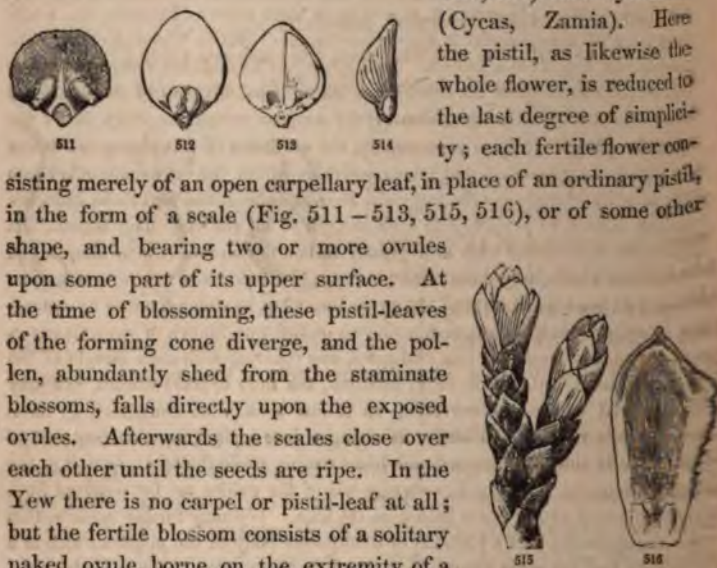


FIG. 511. Scale, i. e. open pistil, from the cone of a Larch, at the time of flowering, or little later; the upper side seen, with its pair of naked ovules.

FIG. 512. Similar view of a Larch scale, when the seeds are partly grown. 513. A mature scale, one of the seeds in its place, the other fallen (reduced in size). 514. A seed detached with its wing.

FIG. 515. Branchlet of the American Arbor-Vitæ, considerably larger than in nature, terminated by its pistillate flowers, each consisting of a single scale (an open pistil), together forming a small cone. 516. One of the scales or pistils removed and more enlarged, the inside exposed to view, showing a pair of naked ovules on its base.

short branch, and surrounded by a few small bracts. As the ovules are here naked and exposed to the direct contact of the pollen, and the seeds are not enclosed in anything answering to a pod, these have received the name of GYMnosPERMOUS PLANTS, that is, plants with naked seeds.

SECT. VIII. THE OVULE.

561. OVULES (420, 543) are bodies borne by the pistil, which, on being fertilized and having an embryo developed in them, become seeds. To their formation, fertilization, and protection all the other parts of the blossom are subservient. They vary greatly in number, from one (*solitary*) in each carpel or cell to a multitude. When few and uniform in number, they are said to be *definite*; when too numerous to be readily counted, *indefinite*.

562. As to situation and direction, they are *erect* when they arise from the very bottom of the cell (Fig. 518); *ascending*, when fixed above its base and rising obliquely upwards (Fig. 517); *horizontal*, when they project from the side of the cell, without turning either upwards or downwards (Fig. 342); *pendulous*, when they hang or turn obliquely downwards (Fig. 387); and *suspended* when hanging perpendicularly from the very summit of the cell (Fig. 519). These terms apply to the seed as well as to the ovule.



563. An ovule is at first a minute projection of the placenta (Fig. 530), of soft and homogeneous parenchyma; but it soon acquires a definite form and structure. It may be either sessile, or raised on a stalk, the FUNICULUS, Podosperm, or seed-stalk. The point of attachment, which in the seed forms the scar, is called the HILUM.

564. It consists of a kernel or *nucleus*, and usually of one or two coats. The nucleus is the essential part of the organ; in it the embryo is formed, and the coats become the integuments of the seed. The ovule of the Mistletoe consists of a naked nucleus only, there being no integument. The ovule of the Walnut has only one

FIG. 517. Ovary of a Buttercup, divided lengthwise, to display its ascending ovule. 518. Same of Buckwheat, with an erect ovule. 519. Same of Anemone, with a suspended ovule.

coat : this appears as a circular ring around the base of the forming nucleus, which gradually becomes cup-shaped, and at length covers it like a sac, remaining open, however, at the summit. This



orifice is called the FORAMEN, or MICROPYLE. In far the greater number of cases, a second envelope is formed outside of the first, beginning in the same way, though always later than the inner one, which, however, it eventually overtakes and encloses. Mirbel named the exterior coat of the ovule the PRIMINE, and the interior the SECUNDINE, — names which are attended with the objection that the secundine or inner coat is actually older than the primine or exterior coat. Both sacs are open at the apex, and the summit of the nucleus points directly towards the apertures. The orifice or foramen of the primine or exterior integument is called the EXOSTOME (or outer orifice) ; that of the interior or secundine, the ENDOSTOME (or inner orifice). The coats of the ovule and the nucleus are distinct and unconnected, except at the base, or point of attachment to the funiculus, where they are all confluent : this point of union receives the name of the CHALAZA (Fig. 521, *d*). Through the funiculus and chalaza the ovule derives its nourishment from the placenta ; through the opening at the summit, the nucleus receives the tubular prolongation of the pollen, which incites

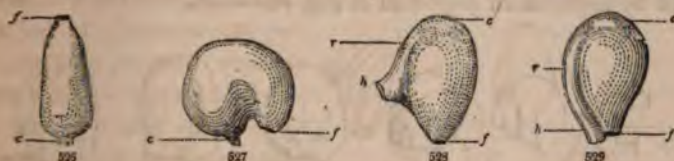
the formation of the embryo.

565. Ovules occur under four principal forms, viz. the *orthotropous* or straight, the *campylotropous* or curved, the *amphitropous* half-inverted, and the *anatropous* or inverted. The simplest, although the least common of these, is

566. The *Orthotropous Ovule*, also termed *atropous* (viz. not turned). It is the form which this organ assumes in the Buckwheat family (Fig. 518), and several others, and is likewise shown in Fig. 520, 526, and a longitudinal section of it in Fig. 521. Here no change

FIG. 520. An orthotropous ovule. 521. Longitudinal section of the same, more magnified, *a*, the primine ; *b*, the secundine ; *c*, the nucleus ; *d*, the chalaza. 522. An amphitropous ovule. 523. Three anatropous ovules, with long funiculi, attached to a portion of the placenta. 524. One of the same, more highly magnified, exhibiting its cellular structure. 525. A campylotropous ovule.

the direction of parts occurs during growth; but the base or chalaza (Fig. 526, *c*) is manifestly the point of attachment, the orifice (*f*) is at the opposite end, and the ovule is straight and symmetrical.



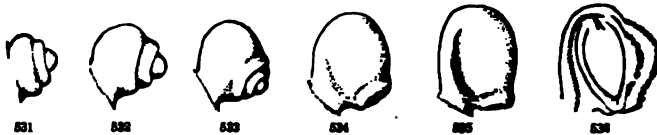
567. The *Campylotropous Ovule* (Fig. 525, 527) is one which grows unequally, and consequently curves upon itself, so as to bring the apex round to the vicinity of the base, the chalaza (*c*) and the orifice (*f*) being at length brought nearly into contact at the point of attachment. Campylotropous or curved ovules are found in the Mignonette, in all Cruciferous and Caryophyllaceous plants, and in many others.

568. The *Anatropous Ovule* (Fig. 517, 519, 523, 524, 529) is far the most common form. It is best described by likening it to an orthotropous ovule which as it grew had inverted itself on its funiculus or support, so that, while the body remains straight, its orifice or apex is brought down to the funiculus and points to the placenta, while the chalaza occupies the apparent or geometrical apex, i. e. the summit or point directly opposite the place of attachment. The ovule, thus inverted on its support, coheres with it for its whole length, and accordingly has a ridge or cord, more or less manifest, along one side (Fig. 529, *r*), connecting the hilum, or place of attachment, and where the seed separates from its insertion (*h*), with the chalaza (*c*). This cord or ridge, which morphologically is merely a continuation of the stalk or support of the ovule adherent to its face on one side, or incorporated with it, is called the *RHAPHE*. It is a distinguishing mark of an anatropous ovule, which is also recognizable by its being straight and by having the orifice close to the point of attachment. The rhapshe itself is often so incorporated with the coat of



- FIG. 525. Orthotropous ovule of Buckwheat: *c*, hilum and chalaza; *f*, orifice.
 FIG. 527. Campylotropous ovule of a Chickweed: *c*, hilum and chalaza; *f*, orifice.
 FIG. 528. Amphitropous ovule of Mallow: *f*, orifice; *h*, hilum; *r*, rhapshe; *c*, chalaza.
 FIG. 529. Anatropous ovule of a Violet; the parts lettered as in the last.
 FIG. 530. Vertical section of a pistil of Magnolia Umbrella, from a young flower-bud, magnified, showing the forming ovule, here a simple protuberance.

the ovule or the seed as to be externally undistinguishable. The seeds of *Magnolia* offer good illustrations of this. The mode of formation and the internal structure of anatropous or inverted ovule will be apparent on inspection of Fig. 530–536.



569. The Amphitropous Ovule (Fig. 522, 528), also called *heterotropous*, differs from the anatropous in having a short raphle (Fig. 528, *r*), extending from the chalaza (*c*) only about half-way to the orifice (*f*). It is attached accordingly by the middle of one side and has the chalaza at one end and the orifice at the other. It may be regarded as a half-anatropous or half-inverted ovule; and all gradations occur between this and the anatropous form, into which it would pass by the cohesion of the side of the ovule with the support a little further down. Amphitropous ovules are general in the *Malvaceae* and the *Primrose* families. As such an ovule stands with its axis at right angles with the funiculus, if there be any, it is also said to be *transverse*.

570. Most of these terms apply to seeds as well as to ovules; and the general structure of the seed may be known beforehand from that of the ovules. We are now prepared to contemplate the process by which an ovule becomes a seed.

SECT. IX. FERTILIZATION AND FORMATION OF THE EMBRYO

571. In order to the formation of the embryo (118), the ovule require to be fertilized by the pollen. Cases of *parthenogenesis*, i. e. of the formation of perfect seed without the agency of pollen, doubtless do sometimes occur, and have been noted in several

FIG. 531. A similar side-view of the ovule of the last, a week or two later, and more enlarged; showing the nucleus encircled by the coats in formation, as two rings or shallow cups within the other. 532 The same, a few days later, more advanced and beginning to turn. 533 The same, further advanced. 534. The same, soon after, with the inversion almost complete, and the outer coat covering the inner, except at the orifice. 535. The complete anatropous ovule from a full-grown flower-bud. 536. A longitudinal section of the same, displaying the raphle, the two coats, and the nucleus.

dicœcious plants. More than half a century ago, Spallanzani found that the pistillate blossoms of Hemp may produce fertile seed without the concurrence of pollen; and recently Naudin and Decaisne have confirmed the fact by experiment, and from seeds produced without fertilization have raised a second generation of plants; the pistillate individuals of which, kept from all access of pollen, have themselves ripened seeds with perfect embryos.* Two or three dicœcious Euphorbiaceous plants are known to produce good seed under the same circumstances, and Naudin has shown it freely to occur in Bryony. Still these are very exceptional cases, and are all confined, so far as known, to dicœcious plants. Ordinarily the access of pollen of the species to the ovules is necessary to the production of the embryo.

572. The Access of the Pollen to the pistil is secured in a great variety of ways and adaptations. In hermaphrodite blossoms the relative length and position of the stamens and stigmas are commonly so adjusted that the pollen may fall directly upon the stigma, the anthers being usually higher than the stigmas when the flower is upright, and shorter when it is nodding. Sometimes pollen is projected upon the stigma by transient and often sudden movements, either mechanical, as in *Kalmia*, or spontaneous and vital, as in the Barberry (to be mentioned in another place). Sometimes fertilization takes place in the bud, where the parts are in apposition, or the anthers are kept in contact with or proximity to the stigma, as in papilionaceous flowers by the enclosing keel-petals, and in the Fumitory family by a close-fitting little sac formed of the united spoon-shaped tips of the two inner petals confining the anthers to the stigma. Very often the pollen is conveyed from the anthers to the stigma by insects, searching for honey or nectar; and there are many species in which fertilization seems absolutely to depend upon the agency of insects; such, for instance, as those of *Aristolochia*, *Asclepias* or Milkweed, and many plants of the *Orchis* family. In dicœcious and many monœcious plants, with widely separated blossoms, fertilization is mainly dependent upon insects, passing from flower to flower, and upon winds and currents. And the immense quantity of pollen which many such plants produce compensates for the greater distance of the passage, and greatly diminishes the chance of failure. The air of a Pine forest in flowering-

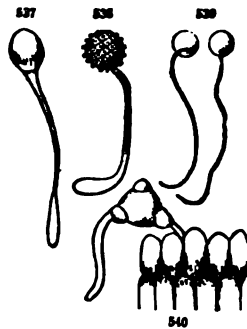
* *Comptes Rendus*, Vol. 43, 1856, and Hooker's *Journal of Botany*, 1857, p. 53.

time is almost loaded with pollen, some of which is often wafted by the winds for many miles.

573. The pollen of Pines and other Gymnospermous plants falls directly upon the naked and exposed ovules (560). On all others, the ovules, being secluded in a closed ovary, can be fertilized only through the stigma. In these, accordingly, we have first to consider.

574. **The Action of Pollen on the Stigma.** The loose papilla, or often the short projecting hairs of the stigma, and the moist surface, serve to retain the grains of pollen on the stigma when they have once reached it. Absorbing some of this moisture, and nourished by it, the grains of pollen which are favorably situated soon begin to grow, or, as we may say, to germinate. The thin inner membrane (534) extends, breaks through the thicker, but weak or brittle, outer coat at some point (or rarely at two or three places), and lengthens into a delicate tube, filled with the liquid and molecular matter that the grain contains. This tube (Fig. 537-540), remaining closed at the extremity, penetrates the loose tissue of the stigma, and is prolonged downwards into the style, gliding along the interspaces between the very loosely disposed cells of the moist conducting tissue (541), which extends from the stigma to the cavity of the

ovary, and at length reaches the placenta, or some other part of the lining of the ovary, and its extremity appears in the cell. This prolongation into a tube, often many hundred times the diameter of the pollen-grain, is a true growth, after the manner of elongating cells (37-97), nourished by the organizable moisture of the style which it imbibes in its course. Now the orifice of the ovules, or a projection of the nucleus beyond the orifice, is at this time brought into contact with, or close



proximity to, that portion of the walls of the ovary from which the pollen-tubes project; and a pollen-tube thus enters the orifice of each ovule, and reaches the nucleus, in which the nascent embryo

FIG. 537. A pollen-grain of *Datura Stramonium*, emitting its tube. 538. Pollen-grain of a *Convolvulus*, with its tube. 539. Other pollen-grains, with their tubes, less strongly magnified. 540. A pollen-grain of the *Evening Primrose*, resting on a portion of the stigma, into which the tube emitted from one of the angles penetrates; the opposite angle also emitting a pollen-tube.

subsequently appears. In Gymnospermous plants (560, 573), the pollen-grains grow at the orifice of the naked ovule, and immediately penetrate its nucleus, just as they do the stigma in ordinary plants.

575. Pollen-tubes may be readily inspected under the microscope in many plants; in none more readily than in the *Asclepias*, or Milkweed, one of the plants in which this subject was so admirably investigated by Mr. Brown. In that family, the pollen-grains of each cell of the anther (Fig. 541) cohere in a mass; and these pollen-masses, dislodged from their cells (Fig. 542, 543), usually by the agency of insects, and brought into proximity with the base of the stigma, protrude their tubes in great abundance. They may be seen to penetrate the base of the stigma, as in Fig. 544, and separate grains with their tubes may be detached from the mass (Fig. 546, 547); but to trace their course down the style (as in Fig. 545), and to their final destination, requires much skill in manipulation and the best means of research.

576. The formation of the pollen-tube commences in some cases almost immediately upon the application of the pollen to the stigma; in others it is not perceptible until after the lapse of from ten to thirty-six hours or more. The rate of the growth of the pollen-tube down the style is also very various in different plants. In some species, a week or more elapses before they have passed through a style even of a few lines in length. In others, a few



FIG. 541. A back view of a stamen of the common Milkweed (*Asclepias*), the appendage cut away. 542. A stamen more magnified, with the two pollen-masses cohering by their caudicles, each to a gland from the summit of the stigmatic body, to which a pollen-mass from an adjacent anther is already adherent. 543. A pair of detached pollen-masses (each from a different anther) suspended by their caudicles from the gland. 544. Some of the pollen-masses, with their tubes penetrating the stigma (after Brown). 545. A section through the large stigmatic body and a part of the summit of one of the styles, showing the course of the pollen-tubes. 546, 547. Pollen-grains with their tubes, highly magnified. (The structure of these singular flowers will be more fully explained under the order *Asclepiadaceæ*.)

hours suffice for their passage through even the longest styles, such as those of *Colchicum*, *Mirabilis* or Four-o'clock, and *Cereus grandiflorus*. After the pollen-tubes have penetrated the stigma, the latter dries up, and its tissue begins to wither or die away, as likewise does the body of the pollen-grain, its whole contents being transferred to the pollen-tube, the lower part of which may still be in a growing condition.

577. Before the pollen-tube has reached the ovule, or more commonly even before the pollen is applied to the stigma, a cavity appears in the interior of the nucleus of the ovule, near its apex. This probably results from the special growth of a particular cell, which expands into a bladder or closed sac, at length commonly occupying a considerable part of the nucleus, — sometimes remaining enclosed in its tissue towards its summit or orifice, sometimes displacing the upper part of the nucleus entirely, or even projecting through the micropyle. This is the *sac of the amnios* of Mr. Brown, the *embryo-sac* (*sac embryonnaire*) of the French botanists. In this sac the embryo is formed.

578. *Origin of the Embryo.* From the latter part of the seventeenth century, when the relative functions of the stamens and the pistils, and something of the structure of the ovule, were demonstrated by Malpighi, Grew, &c., until about the year 1837, it was almost universally supposed that the embryo was a product of the ovule, in some way incited or fertilized by the pollen. One writer, viz. Samuel Morland, had indeed propounded the crude hypothesis, that a pollen-grain itself, descending bodily through the style, was received into the orifice of the ovule, and became the embryo. The absurdity of this view was soon made evident. But how the pollen acted was wholly unknown until Amici, in 1823, discovered pollen-tubes, penetrating the stigma, and Brongniart, Brown, Amici himself, and Schleiden, within the ensuing twelve or fourteen years, had demonstrated their universality, and traced these slender tubes into the ovary, and even to the nucleus of the ovule. Then commenced a spirited controversy, which has only just now been brought to a close. For Professor Schleiden, in the year 1837, advanced the view that the extremity of the tube of the pollen, entering the nucleus of the ovule, there developed into the embryo, — thus anew deriving the embryo or new plant substantially from the pollen instead of the ovule. ^{Amici's} view has recently been abandoned by its indefatigable author. His most able supporter, Schacht, having been thoroughly dis-

proved in all points by a series of elaborate investigations made by Mibtel, Amici, Giraud, Mohl, Hofmeister, Unger, Tulasne, Henfrey, and Radlkofer. So that — passing by the whole history of this long discussion, and merely appending some references to the more important publications upon the subject* — we need only state here, in the most general terms, the principal facts which are now held to be established, viz.:—

579. The pollen-tube terminates on the outer surface of the embryo-sac, or sometimes, perhaps, forces its way into it. Ordinarily its extremity becomes firmly adherent to the surface of the embryo-sac, and it appears to remain closed. Henfrey, indeed, is led to suppose that the membrane of the pollen-tube and that of the embryo-sac are absorbed at the point of contact, and that the former thus discharges its contents into the cavity of the latter; but this is merely an unproved inference, suggested by the analogy of what is now known of the process of fecundation in Cryptogamous plants. At present it appears most probable that the contents of the pollen-tube are drawn into the embryo-sac by endosmosis. However this may be, shortly after reaching the embryo-sac the pollen-tube becomes empty, and decays or withers away. Meanwhile the body which by its development is to give rise to the embryo appears in the embryo-sac independent of the pollen-tube. According to most investigators it generally appears before the pollen-tube has entered the ovule. (The high authority of Tulasne, however, is thus far

* Schleiden first published his famous theory in Wiegmann's *Archiv*, 1837, and in *Acta Nova Acad. Nat. Cur.*, Vol. 19. It was extended and defended in his systematic works, — and especially by Schacht in *Trans. Netherlands Institute*, 1850, in *Bot. Zeitung*, 1855 (transl. in *Ann. Sci. Nat.* of that year), in his *Beiträge Anat. & Phys.*, in his work on the microscope, of which an English translation by Dr. Carrey was published in 1855, and in the *Regensburg Flora*, 1855 (*Ann. Sci. Nat.* 1855). See also Deeeke in *Bot. Zeitung*, 1855 (*Ann. Sci. Nat.*, l. c.). On the other side of the question the most important of the recent publications, since the appearance of Mohl's *Principles of the Anatomy and Physiology of the Vegetable Cell*, in the English translation (1852), and the article *Ovule* in the *Micrographic Dictionary* by Henfrey, are: Hofmeister, in *Flora*, May, 1855, and Mohl, in *Bot. Zeitung*, June, 1855 (both reproduced in *Ann. Sci. Nat.*, ser. 4, Vol. 3, 1855); Tulasne, in *Ann. Sci. Nat.*, ser. 4, Vol. 4, 1855, being the complement of his great memoir published in the same journal (ser. 3, Vol. 12, 1849); Radlkofer, *Die Befruchtung der Phanerogamen*, Leipsic, 1856; Henfrey, *Development of the Ovule of Santalum album*, &c., in *Trans. Linn. Soc.*, Vol. 22, part 1, 1856.

opposed to the pre-existence.) It is a small mass or globule of protoplasmic matter, either loose in the cavity of the embryo-sac near the place to which the pollen-tube is applied externally, or else adherent to the interior surface of the wall of the embryo-sac in this immediate vicinity, or sometimes separated from the embryo-sac by an interposed globule, or by a pair of such globules. This body, the rudiment of the future embryo, has been termed the *embryonal* or

germinal vesicle. This is not yet a cell; for it has no covering or wall of cellulose. But it soon becomes one when a pollen-tube reaches the embryo-sac, the first known result of fertilization being that a coat of cellulose is deposited upon its surface. This newly-formed cell grows by cell-multiplication (33), either producing a mass of cells, as shown in Fig. 10-14, or else in the first place developing into an elongated cell or a thread-shaped chain of cells (the *suspensor*), the lower cell of which divides in all directions, forming a mass, which as it grows shapes itself into the embryo (Fig. 549-553). The radicle or root-end of the embryo is always that by which it is attached to the suspensor (which ordinarily soon disappears) or to the summit of the embryo-sac, the cotyledons occupying the opposite extremity. The radicle accordingly is always directed to the orifice or micropyle of the ovule and seed.



580. Through the fertilization of as many germinal vesicles, two or more embryos are frequently found in the same seed, in the Orange, the Onion, and many other plants. There are generally

FIG. 548. Magnified pistil of Buckwheat; the ovary and ovule divided lengthwise: *s*, pollen on the stigmas, one grain distinctly showing its tube, which has penetrated the style, reappeared in the cavity of the ovary, entered the mouth of the orthotropous ovule (*v*), and reached the embryo-sac (*s*), near the embryonal vesicle (*v*).

two embryos in the seed of the Mistletoe; and there is usually a plurality of embryos in Pines and other Gymnospermous plants (560), though all but one

are more commonly abortive or rudimentary. There are other striking peculiarities in the fecundation of Pines, &c., which, however, cannot be readily explained without entering into more detail than is here advisable.* In Pines and their allies, moreover, the embryo is not developed until a long time after the application of the pollen, and the filling of the embryo-sac with the cellular tissue which forms the basis of the albumen of the seed;

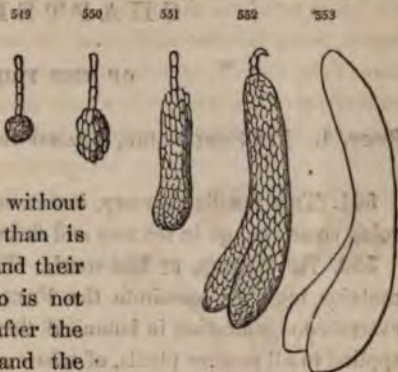
the fruit and seed of true Pines, as is well known, not maturing until the year after that in which the blossoms appear.

580'. The further development and the structure of the embryo and the seed must be considered after the Fruit, of which it constitutes a part.

* See Hofmeister, *Untersuchungen*, &c.: Researches into the Fertilization, &c. of the higher Cryptogamia and the Coniferæ (Leipsic, 1851), with seven plates devoted to the embryology of Coniferæ.

FIG. 549. Diagram of the suspensor and forming embryo at its extremity. 550. The same, with the embryo a little more developed. 551. The same, more developed still, the cotyledons faintly indicated at the lower end. 552. Same, with the incipient cotyledons more manifest. 553. The embryo nearly completed.

FIG. 554-556. Forming embryo from a half-grown seed of Buckwheat, in three stages. 557. Same, with the cotyledons fully developed.



CHAPTER X.

OF THE FRUIT.

SECT. I. ITS STRUCTURE, TRANSFORMATIONS, AND DEHISCENCE.

581. THE fertilized ovary, increased in size, and usually undergoing some change in texture and form, becomes

582. The *Pericarp*, or *Seed-vessel*. The pericarp and the seeds it contains together constitute the *FRUIT*; a term which has a more extensive signification in botanical than in ordinary language, being applied to all mature pistils, of whatever form, size, or texture. To the fruit likewise belongs whatever organs may be adnate to the pistils (468). Such incorporated parts, like the fleshy calyx of the Apple and Quince (Fig. 809, 812), sometimes make up the principal bulk of the fruit.



558



559

583. Indeed, the calyx, when wholly free from the pistil, sometimes becomes greatly thickened and pulpy after flowering, and is transformed into what appears like a berry; as in *Gaultheria* (Fig. 913), where the real fruit is a dry pod within; and in *Strawberry Blite* (Fig. 1099), where the fleshy calyxes of a head of flowers each surround a small seed-like fruit, and together form a false multiple fruit, resembling a strawberry.

584. Even the strawberry itself is not a fruit in the strict botanical sense: that is, the edible substance is not a ripened pistil, nor a cluster of pistils, but is the receptacle or extremity of the flower-stalk, greatly enlarged and replete with delicious juice; the true fruits being the minute and seed-like ripened ovaries scattered over its surface; as plainly appears from a comparison of Fig. 558 with 559. Moreover, a mulberry,

FIG. 558. Vertical section of a forming strawberry, enlarged.

FIG. 559. Similar section of one half of a ripe strawberry, and of some of the small seed-like fruits, or achenia, on its surface.

a fig, and a pine-apple consist of the ripened products of many flowers, crowded on an axis or common receptacle, which makes a part of the edible mass.

585. Under the general name of fruit, therefore, even as the word is used by the botanists, things of very different structure or of different degrees of complexity are confounded. We must distinguish, therefore, between *simple fruits*, resulting from a single flower, and a *multiple fruit*, resulting from the parts of more than one flower combined or collected into a mass. We must also distinguish between true fruits, formed of a matured pistil, either alone or with a calyx, &c. adnate to it, and fruits, so called, of which the pericarp does not form an essential part.

586. *Obliteration or Alteration.* The pericarp, being merely the pistil matured, should accord in structure with the latter, and contain no organs or parts that do not exist in the fertilized ovary. Some alterations, however, often take place during the growth of the fruit, in consequence of the abortion or obliteration of parts. Thus, the ovary of the Oak consists of three cells, with a pair of ovules in each; but the acorn, or ripened fruit, presents a single cell, filled with a solitary seed. In this case, only one ovule is matured, and two cells and five ovules are suppressed. The ovary of the Horsechestnut and Buckeye is similar in structure (Fig. 777-780), and seldom ripens more than one or two seeds; but the abortive seeds and cells may be detected in the ripe fruit. The ovary of the Birch and of the Elm is two-celled, with a single ovule in each cell: the fruit is one-celled, with a solitary seed; one of the ovules or young seeds being uniformly abortive, while the other in enlarging thrusts the dissepiment to one side, so as gradually to obliterate the empty cell; and similar instances of suppression in the fruit of parts actually extant in the ovary are not uncommon. On the other hand, there are sometimes more cells in the fruit than properly belong to the pistil. For instance, the ovary of *Datura Stramonium* is two-celled; but the fruit soon becomes spuriously four-celled by a false partition connecting each placenta with the dorsal suture. So the compound ovary of Flax when young is five-celled, but with a strong projection from the back of each cell (Fig. 500) which at maturity divides the cell into two, thus rendering the fruit ten-celled. And some legumes are divided transversely into several cells, although the ovary was one-celled with a large cavity in the flower.

587. **Ripening.** The pericarp sometimes remains herbaceous in texture, like the pea-pod, or becomes thin, dry, and membranaceous, like the pod of the Bladder-Senna. In such cases it is furnished with stomates, continues to have chlorophyll in its cells, and acts upon the air like an ordinary leaf. In other plants the pericarp thickens, and either becomes hard and dry, like a nut, or else fleshy or pulpy, like a berry (gooseberry, grape, &c.). Sometimes the outer portion softens into flesh or pulp, while the inner portion hardens, thus forming a stone-fruit, like the cherry and peach.

587'. Most fleshy or pulpy fruits are tasteless or slightly bitter during their early growth; at which period their structure and chemical composition are similar to that of leaves, consisting of cellular with some woody tissue; and their action upon the atmosphere is likewise the same (346). In their second stage, they become sour, from the production of acids (353); such as tartaric acid in the grape; the citric, in the lemon, orange, and the cranberry; the malic, in the apple, gooseberry, &c. At this period they exhale very little oxygen, or even absorb that substance from the surrounding air. The acid increases until the fruit begins to ripen, when it gradually diminishes, and sugar is formed. In the third stage, or that of ripening, the acids, as well as the fibrous and cellular tissues, gradually diminish as the quantity of sugar increases; the latter being produced partly at the expense of the former. A chemical change, similar to that of ripening, takes place when the green fruits are cooked; the acid and the mucilaginous or other products, by the aid of heat reacting upon each other, are both converted into sugar. Mingled with the saccharine matter, a large quantity of *vegetable jelly* (83) is also produced in most acidulated pulpy fruits, existing in the form of *pectine* and *pectic acid*. These arise from the reaction of the vegetable acids during ripening upon the dextrine and other ternary products accumulated in the fruit.

588. When the walls of a pericarp form two or more layers of dissimilar texture, the outer layer is called the *Epicarp*, the middle one, *Mesocarp*, and the innermost, *Endocarp*. A stone-fruit or *drupe*, like the peach, consists of two layers, viz. the outer or fleshy layer, which is therefore termed the *Sarcocarp*, and the inner, or endocarp, the shell or stone, which is also termed the *Putamen*.

589. Fruits also may be divided into the *indehiscent* or closed, and the *dehiscent* or those that open. Fleshy fruits generally, stone-fruits, and many dry fruits, especially one-seeded ones, such as nuts,

achenia, &c., remain indehiscent; while most pods or capsules *dehisce* at maturity.

590. Some pods burst irregularly when ripe and dry; others open and shed their seeds by definite pores, as the Poppy, or by larger holes, chinks, or valves, as the Campanula, Snapdragon, &c.; or by a transverse line cutting off the top of the pod, as in Henbane and Purslane. These are modes of *irregular dehiscence*. But

591. *Dehiscence*, when regular and normal, is effected by a vertical separation or splitting, viz. by the opening of one or both sutures of the ovary (543), or, in a fruit resulting from a compound ovary (548), by the disjunction of the united parts. The several modes of dehiscence will be characterized under the kinds of fruit in which they occur (607–614).

SECT. II. THE KINDS OF FRUIT.

592. THE various kinds of fruits have been minutely classified and named; but the terms in ordinary use are not very numerous. A rigorously exact and particular classification, discriminating between the fruits derived from simple and from compound pistils, or between those with and without an adnate calyx, becomes too recondite and technical for practical purposes. It is neither convenient nor philosophical to give a substantive name to every variation of the same organ. For all ordinary purposes it will suffice to characterize the principal kinds under the four classes of *Simple*, *Aggregate*, *Accessory* or *Anthocarpous*, and *Multiple Fruits*.

593. *Simple Fruits* are those which result from the ripening of a single pistil, whether with or without a calyx or other parts adnate to it. This division comprises most of the kinds of fruit which have distinctive names, and those of the other classes are mainly aggregations or combinations of these.

594. *Simple Fruits* may be conveniently divided into *Fleshy fruits*, *Stone fruits*, and *Dry fruits*. The leading kind of the first division is

595. The *Berry* (*Bacca*), an indehiscent fruit which is fleshy or pulpy throughout. The grape, gooseberry, currant, cranberry, and tomato are familiar examples.

596. The *Hesperidium* (orange, lemon, and lime) is merely a berry with a leathery rind.

597. The *Pepo*, or *Gourd-fruit*, is also a modification of the berry, with a hard rind, which occurs in the Gourd family. The cucumber, melon, and squash are familiar illustrations. A *Pepo* is an indehiscent, externally firm and internally pulpy fruit, composed usually of three carpels, and with an adnate calyx. In the ovary it is either one-celled with three broad and revolute parietal placentae, or these placentae, borne on slender dissepiments, meet in the axis, enlarge, and spread, unite with their fellows on each side, and are reflected to the walls of the pericarp, next which they bear their ovules (Fig. 560, 561). As the fruit enlarges, the seed-bearing

placentae usually cohere with the walls, and the partitions are obliterated, giving the appearance of a peculiar abnormal placentation, which only the study of the ovary readily explains.

598. A *Pome*, such as the apple, pear, and quince (Fig. 809, 812), is a fruit composed of two or more carpels, either papery, cartilaginous, or bony, usually more or less involved in a pulpy expansion of the receptacle or disk, and the

whole invested by the thickened and succulent tube of the calyx. It may be readily understood by comparing a rose-hip with an apple. The calyx makes the principal thickness of the flesh of the apple, and the whole of that of the quince.

599. The *Drupe*, or *Stone-Fruit*, is a one-celled, one or two seeded indehiscent fruit, with the inner part of the pericarp (*endocarp*, or *putamen*, 588) hard or bony, while the outer (*exocarp*, or *sarcocarp*) is fleshy or pulpy. It is the latter which in these fruits so readily takes an increased development in cultivation. The name is strictly

FIG. 560. Section of the ovary of the Gourd. 561. Diagram of one of its constituent carpels. FIG. 562. Vertical section of a peach. 563. An almond; where the *exocarp*, the portion of the pericarp that represents the pulp of the peach, remains thin and juiceless, and at length separates by dehiscence from the *endocarp*, or shell.



applicable only to fruits produced by the ripening of a one-celled pistil; as the plum, peach (Fig. 562), &c.; but it is extended in a general way to such fruits with two or more bony cells enclosed in pulp, as that of the Dogwood, &c.

600. The raspberry and blackberry (Fig. 564) are composed of a great number of miniature stone-fruits, or *drupelets*, as they might be called, in structure resembling cherries (Fig. 565), aggregated upon an elongated receptacle.

601. Dry Fruits may be either *dehiscent* or *indehiscent* (589). Of indehiscent dry fruits one of the simplest kinds is

602. The Achenium, or Akene (Fig. 566-573).

This includes all one-seeded, dry and hard, indehiscent and seed-like, small fruits, such as are popularly taken for naked seeds. But that they are true pistils or ovaries ripened is evident from the styles or stigmas they bear, or from the scar left by their fall; and a section brings to view the seed within, provided with its own proper integuments. The name has been restricted to the seed-like fruits of simple pistils, as those of the Buttercup (Fig. 566, 567), Anemone, Clematis, and Geum (where the persist-



FIG. 564. Magnified vertical section of half of a blackberry. 565. Section of one of the grains, or *drupelets*, more magnified.

FIG. 566. Achenium of a common Buttercup, enlarged. 567. Vertical section of the same, showing the seed within.

FIG. 568. Achenium of Mayweed (no pappus). 569. That of Clehory (its pappus a shallow cup). 570. Of Sunflower (pappus of two deciduous scales). 571. Of Sneezeweed (*Helenium*) with its pappus of five scales. 572. Of Sow-Thistle, with its pappus of delicate downy anellion, its pappus raised on a long beak.

ent style usually remains on the fruit as a long tail), and the minute grains of the strawberry (Fig. 559). But it may be extended, as is now generally done, to all such one-celled seed-like fruits resulting from a compound ovary, and even when invested with an adnate calyx-tube. Of this kind is the fruit of all Compositæ (Fig. 568-573). Here the tube of the calyx is incorporated with the surface of the ovary, and its limb or border, obsolete in some cases (Fig. 568), in others appears as a *crown* (Fig. 569), cup, a set of teeth or of scales (Fig. 570, 571), or as a tuft of bristles or hairs (Fig. 572, 573), &c., called the *pappus*. In the Lettuce and Dandelion (Fig. 573), the achenium is *rostrate*, i. e. its summit is extended into a slender beak.

603. A *Utricle* is the same as an achenium, only with a thin and bladdery loose pericarp, like that of Goosefoot and Amaranth (Fig. 574, 575). The thin coat commonly bursts irregularly, discharging the seed. In the true Amaranths it opens by a circular line, and the upper part falls as a lid, converting the fruit into a small *pyxis* (619).



604. A *Caryopsis* or *Grain* differs from the last in having the seed completely filling the cell, and its coat firmly consolidated throughout with the very thin pericarp, as in wheat, Indian corn, and other cereal grains (Fig. 622-624). Of all fruits this is the kind most

likely to be mistaken for a seed.

605. A *Nut* is a hard, one-celled and one-seeded, indehiscent fruit, like an achenium, but larger, and usually produced from an ovary of two or more cells with one or more ovules in each, all but a single ovule and cell having disappeared during its growth (586); as in the Hazel, Beech, Oak (Fig. 576, 1166), Chestnut, Cocoa-nut, &c. The nut is often enclosed or surrounded by a kind of involucre, termed a *Cupule*; as the cup at the base of the acorn, the bur of the chestnut, and the leaf-like covering of the hazel-nut.



FIG. 574. Utricle of *Chenopodium album*, or common Goosefoot. 575. Utricle, or *pyxis*, of an Amaranth.

FIG. 576. Acorn (nut) of White Oak, with its cup or cupule.

and Ash (Fig. 577). The fruit of the Maple consists of two such fruits belonging to one flower, united by their bases (Fig. 787).

607. **Dehiscent Fruits, or Pods**, are distinguishable into those consisting of a simple pistil, and those resulting from a compound pistil.

608. Of those originating from simple pistils, the principal kinds are the *Follicle* and the *Legume*. These may be taken as the type, of simple fruits.

609. A *Follicle* is a pod formed of a simple pistil, and dehiscent by the ventral or inner suture alone; as in the Milkweed, Larkspur, Columbine, Peony, and Marsh-Marigold (Fig. 579). When it opens widely, the pistil may be said to revert to its natural state of a leaf, and it often looks much like one, as in Fig. 492.

610. A *Legume* is a pod formed by the ripening of a simple pistil which dehisces by both sutures, and so divides into two *valves* or pieces, as in the Bean and Pea (Fig. 580). This being the ordinary

fruit of the Pulse family, accordingly named *Leguminosæ* (or Leguminous plants), the name has been extended to it in descriptive botany, in all cases, whatever the form, and whether dehiscent or not. The legume will be found to exhibit no small diversity in this large family (799). Among its forms is one termed

611. A *Loment*. This is a legume divided transversely into two or more one-seeded joints, which usually fall apart at maturity (Fig. 581). Commonly these joints remain closed, as in *Desmodium*; sometimes they split into two valves, as in *Mimosa*.

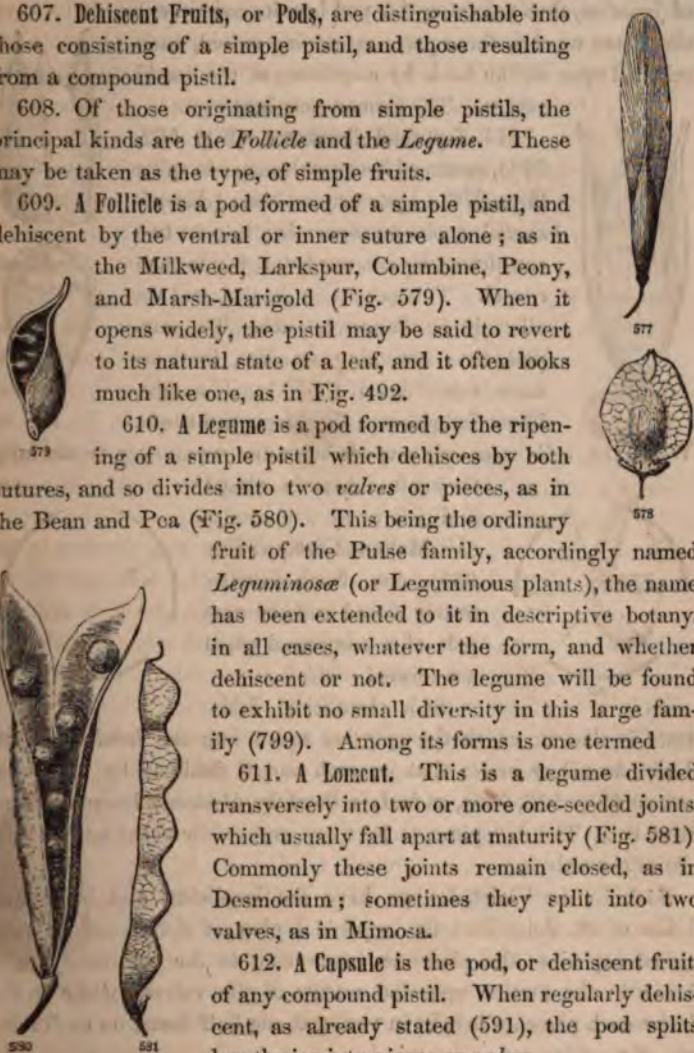
612. A *Capsule* is the pod, or dehiscent fruit, of any compound pistil. When regularly dehiscent, as already stated (591), the pod splits lengthwise into pieces or *valves*.

613. A *Capsule*, necessarily consisting of two or more carpels or

FIG. 577. Samara of White Ash. 578. Samara of American Elm.

FIG. 579. Follicle of *Caltha palustris*, the Marsh-Marigold.

FIG. 580. Legume of a Sweet Pea, already dehiscent. 581. Loment of a Tick-Trefoil or *Desmodium*.



simple pistils united into one body, will normally dehisce in one of two ways. Namely, either the carpels will separate at the line of junction, thus resolving the pod into its constituent elements; or else, these parts remaining united, each cell will open on the back by a splitting of the dorsal suture. The former constitutes



614. **Septicidal Dehiscence** (Fig. 582, 584), so named because the capsule splits through the *septa* or *partitions* (*dissepiments*), each one separating into its two constituent layers, one belonging to each carpel. This occurs in Azalca and its allies, in St. Johnswort, &c. The carpels, thus becoming separate, in these cases open down their inner suture, like a follicle, and discharge the seeds.



When the cells are only one-seeded, after separating septicidally, they often remain closed and fall away separately, as in Mallow, Vervain (Fig. 985), &c. Such closed or nearly closed cells or carpels of a compound pistil are termed *cocci*.



615. **Loculicidal Dehiscence**

is that in which the splitting opens into the *loculaments* (in Latin, *loculi*) or cells; that is, each carpel dehisces by its dorsal suture (Fig. 583, 585), as in Iris, the Lily, Hibiscus, Evening Primrose, &c. The dissepiments here are necessarily borne on the middle of the valves.

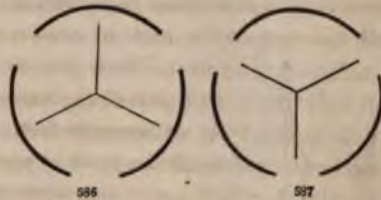
616. In the Violet, &c. we have the loculicidal, and in several kinds of St. Johnswort the septicidal, plan of dehiscence in one-celled capsules; the placentæ (answering to the partitions) being borne in the former upon the middle of the valves; while in the latter each placenta is split in two, and one half borne on each margin of a valve.

FIG. 582. Dehiscent capsule of *Elodea*, enlarged, showing septicidal dehiscence.

FIG. 583. Dehiscent capsule of *Iris*, showing loculicidal dehiscence; the lower part across, showing the dissepiments borne on the middle of the valves.

FIG. 584. Diagram (in cross-section) of septicidal, and, 585, of loculicidal, dehiscence.

617. **Septifragal Dehiscence** is a modification of either the loculicidal or the septicidal, in which the valves fall away, leaving the dissepiments behind attached to the axis. Fig. 586 is a diagram representing this in a case of loculicidal opening. Fig. 587, from the common Morning-Glory, is this modification of the septicidal mode.



618. Instead of splitting into separate pieces, the sutures of the pericarp sometimes open for a short distance at their apex only, as in *Cerastium* and some other Chickweeds, in Tobacco (Fig. 1050), and in the Primrose (Fig. 943); or by mere pores, as in the Poppy. The pod of the Snapdragon opens by the bursting of a hole towards the top of each cell, not corresponding, perhaps, with any suture. Another anomalous mode of dehiscence, namely, the *circumcissile*, characterizes

619. The **Pyxis** or **Pyxidium**, a pod which opens by a circular horizontal line cutting off the upper part as a lid. The fruits of the Plantain, Henbane, Amaranth (Fig. 575, which is otherwise a utricle), Pimpernel, and Purslane (Fig. 588) are of this kind.

620. A **Silique** is a slender two-valved capsule, with two parietal placentae, from which the valves separate in dehiscence; as in plants of the Cruciferous or Mustard family (Fig. 589), to the fruit of which the term properly belongs. Usually a false partition is stretched across between the two placentae, rendering the pod two-celled in an anomalous manner.

621. A **Silicle** or **Pouch** is merely a short silique, its length not more than twice its breadth; as that of Shepherd's-Purse, Candytuft, &c.

622. **Aggregate Fruits** are those in which a cluster of carpels, all belonging to one flower, are crowded on the receptacle into one mass, as in the raspberry and blackberry taken as a whole (Fig. 564), where the constituent fruits, or ripened carpels,



FIG. 586. Septifragal modification of loculicidal, and, 587, of septicidal, dehiscence.

FIG. 588. Pyxis or pod of Purslane, *the*

FIG. 589. Silique of Cardamine, in d

are little drupes; also the cone-like fleshy fruit of *Magnolia*, where the component carpels are a sort of drupaceous follicles, at length opening on the back and summit; and the dry cone of the Tulip-tree, where each carpel forms a sort of samara. None of these aggregate fruits have special names in ordinary use. In descriptive botany it is sufficient to state the kind of fruit the carpels themselves form, and their mode or degree of aggregation.

623. **Accessory or Anthocarpous Fruits** are those of which the most conspicuous portion, although often appearing like a pericarp, neither belongs to the pistil nor is organically united with it. The apparent berry of *Gaultheria*, in which a succulent free calyx invests a dry pod and appears to form the real fruit (Fig. 912-914) has already been adverted to (583); and the calyx of *Shepherdia* is similar, forming what appears to be the sarcocarp of a drupe, although it is really free from the achenium it encloses. So, also, the apparent achenium or nut of *Mirabilis*, or Four-o'clock, is the thickened and indurated base of the tube of a free calyx, which contracts at the apex and encloses the true pericarp as a utricle or thin achenium, but does not cohere with it. The rose-hip, a hollow calyx-tube lined with a hollow receptacle (Fig. 429), and the strawberry (Fig. 428, 558, 559), consisting of a conical enlarged receptacle bearing many minute achenia, may also be regarded as forms of anthocarpous fruit.

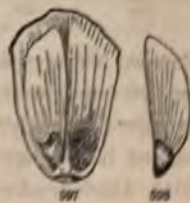
624. **Multiple or Collective Fruits** are those which result from the aggregation of several flowers into one mass. The simplest of these are those of the Partridge-Berry (*Mitchella*) and of some species of Honeysuckle (Fig. 859), consisting of the ovaries of two blossoms united into one double berry. The more usual sorts are such as the pine-apple, mulberry, and the fig. These are, in fact, dense forms of inflorescence, with the fruits or floral envelopes matted together or coherent with each other; and all or some of the parts become succulent. The grains of the mulberry (Fig. 593, 594) are not the ovaries of a single flower, like those of the blackberry which it superficially resembles (Fig. 564), but belong to as many separate flowers; and the pulp of these pertains to the floral envelopes instead of the pericarp. So that the mulberry is an anthocarpous (623) as well as a multiple fruit. The pine-apple is very similar; only the ovaries or pericarps never ripen any seeds, but all are blended, with the floral envelopes, the bracts, and the axis of the stem they thickly cover, into one fleshy and juicy mass. The fig (Fig. 590-592)

differs from the pine-apple in having this succulent axis or receptacle



on the outside. It may be compared with such an anthocarpous fruit as a rose-hip (Fig. 429). It results from a multitude of flow-

ers concealed in a hollow flower-stalk, if it may be so called, which becomes pulpy and edible when ripe; and thus the *fruit* seems to grow directly from the axil of a leaf, without being preceded by a blossom. The minute flowers concealed within, or some of them, ripen their ovaries into very small achenia, which are commonly taken for seeds. The principal form of multiple fruit which has received a substantive name is



625. The Strobile or Cone, a scaly multiple fruit, resulting from the

FIG. 590 A young fig. 591. Vertical section of the same, enlarged. 592. A small slice of the same, more magnified, showing the flowers on the inside.

FIG. 593. A young mulberry. 594. One of the grains, magnified, showing it to be a pistillate flower, with a succulent calyx embracing the ovary. 595. The same, less magnified, the succulent calyx cut away.

FIG. 596. Strobile or Cone of a Pitch Pine, *Pinus rigida*. 597. Two scales, showing one of the seeds, and the place from which the strobile, &c.

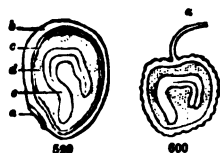
ripening of some sort of catkin. The name is applied to the fruit of the Hop, where the large and thin scales are bracts; but it more especially belongs to the Pine or Fir cone, the peculiar fruit of *Coniferæ* (Fig. 596), the scales of which are open carpels (560), bearing two or more naked seeds upon their upper or inner face (Fig. 597). A more or less fleshy and closed cone, such as that of *Taxodium*, and especially that of Juniper (Savin, Red Cedar, &c.), which at maturity imitates a berry, has been termed a *GALBALUS*.

CHAPTER XI.

OF THE SEED.

SECT. I. ITS STRUCTURE AND PARTS.

626. The Seed, like the ovule (561), of which it is the fertilized and matured state, consists of a *NUCLEUS*, or kernel, usually enclosed within two *INTEGUMENTS*.



627. Its *Integuments*, &c. The outer, or proper seed-coat, corresponding to the exterior coat of the ovule, is variously termed the *EPISPERM*, *SPERMODERM*, or more commonly the *TESTA* (Fig. 599, *b*). It varies greatly in texture, from membranaceous or papery to crustaceous or bony (as in the Papaw, Nutmeg, &c.), and also in form, being sometimes closely applied (conformed) to the nucleus, and in other cases loose and cellular (as in *Pyrola*, Fig. 927, and *Sullivantia*, Fig. 843), or expanded into wings (as in the *Catalpa* and *Trumpet-Creeper*, Fig. 601), which render the seeds buoyant, and facilitate their dispersion by the wind; whence winged seeds are only met with in deliscent fruits. The wing of the seed of Pines (Fig. 598) is a part of the surface of the scale or carpel to which it is attached, and which separates with it. For the same purpose, the testa is sometimes

FIG. 599. Vertical magnified section of the (anatropous) seed of the American Linden: *a*, the hilum; *b*, the testa; *c*, the tegmen; *d*, the albumen; *e*, the embryo. 600. Vertical section of the (orthotropous) seed of *Helianthemum Canadense*: *a*, the funiculus.

provided with a tuft of hairs at one end, termed a *Coma*; as in *Epilobium* and Milkweed (Fig. 602). In the Cotton-plant, the whole surface of the seed is covered with long wool.

It should likewise be noticed, that the integument of numerous small seeds is furnished with a coating of small hairs containing spiral threads (one form of which is represented in Fig. 44), and usually appressed and confined to the surface by a film of mucilage. When the seed is moistened, the mucilage softens, and these hairs spread in every direction. They are often ruptured, and the extremely attenuated elastic threads they contain uncoil, and are protruded in the greatest abundance and to a very considerable length. This minute mechanism subserves an obvious purpose in fixing these small seeds to the moist soil upon which they lodge, when dispersed by the wind. Under the microscope, these threads may be observed on the seeds of most Polemoniaceous plants, and on the achenia of Labiate and Composite plants, as, for example, in many species of *Senecio*, or Groundsel. In *Peony* the testa becomes fleshy or baccate; in *Magnolia* it imitates a drupe.

628. The inner integument of the seed, called the *TEGMEN* or *ENDOPLEURA*, although frequently very obvious (as in Fig. 599, *c*), is often indistinguishable from its being coherent with the testa, and is sometimes altogether wanting.

629. The *stalk* of the seed, as of the ovule, is called the *FUNICULUS* (Fig. 600, *a*). The scar left on the face of the seed, by its separation from the funiculus at maturity, is termed the *HILUM*. The chalaza and rhaphe, when present, are commonly obvious in the mature seed, as well as in the ovule (564–568), and the name and relations of these several parts in the seed are the same as in the ovule. Also the terms *orthotropous*, *anatropous*, *campylotropous*, &c., originally applied to the ovules, are extended to the seeds which result from them; so that we may say, Seeds anatropous, as well as Ovules anatropous, &c.

630. *Aril* or *Arillus*. Some seeds are furnished with a covering, (usually incomplete and of a fleshy texture,) wholly exterior to their proper integuments, arising from an expansion of the apex of the



FIG. 601. The winged seed of Trumpet-Creeper.

FIG. 602. Seed of Milkweed (*Asclepias Cornuti*), with its coma or tuft.

seed-stalk, or funiculus, or of the placenta itself when there is no manifest seed-stalk. This is called the **ARIL**. It forms the pulpy envelope of the seed of *Podophyllum*, *Euonymus*, and *Celastrus*, or it appears as a mere lateral scale in *Turnera*, or as a tough and lacerated body, known by the name of *mace*, in the Nutmeg. In the White Water-Lily it is a thin and delicate cellular bag, open at the end (Fig. 603). The Aril does not appear in the ovule, but is developed subsequent to fertilization, during the growth of the seed. Of



the same or similar nature is the **CARUNCLE** found at the hilum in *Polygala*, forming a loose lateral appendage. Strictly speaking, it is to be distinguished from the **STROPHIOLE** (like that of *Euphorbia*), which is a cellular growth from the micropyle; but the two are not well discriminated. An analogous cellular growth takes place on the rraphe of the Bloodroot, of the Prickly Poppy, and of *Dicentra*, forming a conspicuous crest on the whole side of the seed.

631. The **Nucleus**, or **Kernel** of the seed, consists of the **ALBUMEN**, when this substance is present, and the **EMBRYO**.

632. The **Albumen**, which has also been termed the *Perisperm* or the *Endosperm*, has already been described (125) as the floury part of those seeds in which an amount of nourishment for the germinating plantlet is stored up outside of the embryo. This was called by Gartner the *albumen* of the seed, from some fancied analogy with the white of an egg as to situation or function;—an unfortunate term, on account of its liability to be confounded with the quaternary chemical substance of the same name (357), one of the forms of proteine. Being in general use, the term cannot now well be discarded.

633. The *Albumen* of the seed consists of whatever portion of the tissue of the ovule persists, and becomes loaded with nutritive matter accumulated in its cells,—sometimes in the form of starch-grains principally, as in wheat and the other cereal grains; sometimes as a continuous, often dense, incrusting deposit, as in the coconut, the date, the coffee-grain, &c. When it consists chiefly of starch-grains, and may readily be broken down into a powder, it is said to be *farinaceous*, or *mealy*, as in the cereal grains generally, in buckwheat, &c. When a fixed oil is largely mixed with this, it becomes *oily*, as in the seed of the Poppy, &c.; when more compact, but still capable of being readily cut with a knife, it is *fleshy*, as in

FIG. 603. A seed of the White Water-Lily, with its sac-like arillus, magnified.

the Barberry, &c.; when it chiefly consists of mucilage or vegetable jelly, as in the Morning-Glory and the Mallow, it is said to be *mucilaginous*; when it hardens more, and becomes dense and tough, so as to offer much resistance to the knife, as in the Coffee, the Blue Cohosh, &c., it is *corneous*, that is, of the texture of horn. Between these all gradations occur. Commonly the albumen is a uniform deposit. But in the nutmeg, as also in the seeds of the Papaw (Fig. 658), and of all plants of the Custard-Apple Family, it presents a wrinkled or variegated appearance, owing to numerous transverse divisions, which are probably caused by inflections of the innermost integument of the seed: in these cases the albumen is said to be *ruminated*. The albumen may originate from new tissue formed either within the embryo-sac (579), which is probably the more common case; or in the nucleus of the ovule exterior to the embryo-sac, which is certainly the case in the Water-Lily and its allies, and in Saururus; for here the thickened embryo-sac persists within or at one extremity of the copious albumen; or both kinds may coexist. When this is the case, the outer albumen may be distinguished as the *perisperm*, and the inner as the *endosperm*.

634. Seeds provided with albumen (as in Fig. 599, 600, 605, 606, 609, 610–616, 622, &c.) are said to be *albuminous*; those destitute of it (as in Fig. 607, 629, 110, 120, &c.) are *exalbuminous*. The comparative amount of the albumen, and its relation to the embryo in various seeds, may be seen on inspection of many of the subjoined figures.



635. The Embryo, or Germ, being an initial plantlet or individual, is of course the most important part of the seed: to its production, protec-

FIG. 604. Seed of a Violet (anotropous), enlarged: *a*, hilum or scar; *b*, rhaphe; *c*, chalaza.

FIG. 605. Vertical section of the same, showing the straight embryo in the axis of the mealy albumen.

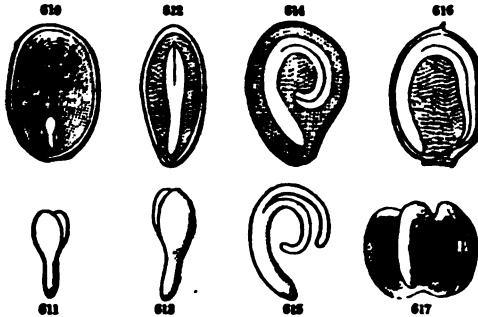
FIG. 606. Vertical section of the (orthotropous) seed of Buckwheat, showing the embryo folded round in the mealy albumen.

FIG. 607. Vertical section of the (anotropous) seed of Elodea Virginica, the embryo completely filling the coats.

FIG. 608. Seed of Delphinium tricornes (anotropous), enlarged; *a*, the hilum; *b*, the rhaphe; *c*, the chalaza. 609. Vertical section of the same: *c*, the chalaza; *d*, the testa; *e*, the tegmen; *f*, the albumen; *g*, the minute embryo near the hilum, *a*.

tion, and support all the other parts of the fruit and flower are subservient. It becomes a plant by the mere development of its parts: it therefore possesses, in a rudimentary or undeveloped state, all the essential organs of vegetation, namely, a root, stem, and leaves. Its general structure and development have already been explained in considerable detail (118 – 130).

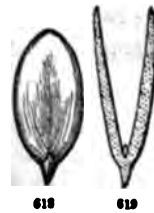
636. In albuminous seeds it is naturally the smaller and its parts the less developed in proportion to the amount of albumen, and the



several organs are developed or even formed in germination. In exalbuminous seeds, where the embryo constitutes the whole kernel, its several parts are ordinarily conspicuous, although they are

often more or less disguised by thickening; as the cotyledons in the Almond (Fig. 108) and Cherry (Fig. 111), and especially in the Pea (Fig. 118), the Acorn (Fig. 120), the Horsechestnut (Fig. 630), and the like.

637. The parts of the embryo, as already illustrated (120) are the *Radicle*, the *Cotyledons*, and the *Plumule*. The radicle is the axis, or rudimentary stem, — the first internode of the axis (121, 157), from the lower extremity of which the root is produced, while the other bears the cotyledons, i. e. the leaves of the first node; and the plumule is the bud which crowns the summit of the radicle.



638. Owing to the mode of its formation (580), the radicle of the

FIG. 610. Vertical section of the seed of a Peony, showing a small embryo near the base of the copious albumen. 611. The embryo, detached, and more magnified.

FIG. 612. Section of a seed of Barberry, with a straight embryo in the axis of the albumen. 613. Its embryo, detached.

FIG. 614. Section of a Potato-seed, showing the embryo coiled in the albumen. 615. Its embryo, detached.

FIG. 616. Section of the seed of Mirabilla or Four-o'clock, showing the embryo coiled round the outside of the albumen. 617. Its embryo, detached, and partly spread out.

FIG. 618. Embryo of the Pumpkin, with its short radicle and large and flat cotyledons, seen flatwise. 619. A vertical section of the same, viewed edgewise.

embryo is always near to and points towards the micropyle of the seed, viz. to what was the orifice of the ovule; and if the embryo be straight (as in Fig. 605), or merely partakes of the curvature of the seed, the cotyledons point to the opposite extremity of the seed, that is, to the chalaza. The position of the radicle as respects the hilum varies with the different kind of seed. In the orthotropous form, as in *Helianthemum* (Fig. 600) and Buckwheat (Fig. 606), the radicle necessarily points directly away from the hilum. In the anatropous form, as in the seed of the Linden (Fig. 599) and Violet (Fig. 604, 605), the extremity of the radicle is brought to the immediate vicinity of the hilum; and so it is, although in a different way in the campylotropous seed (Fig. 620, 621); while in the amphitropous, the radicle points away from the hilum laterally, at a right angle to the funiculus. As the nature of the ovule and seed may usually be ascertained by external inspection, so therefore the situation of the embryo within, and of its parts, may often be inferred without dissection. But the dissection of seeds is not generally a difficult operation.



639. The position of the embryo as respects the albumen, when that is present, is various. Although more commonly in the axis, it is often *excentric*, or even external to the albumen, as in all Grasses and cereal Grains (Fig. 622–624), in *Polygonum* (Fig. 1111), &c. When external or nearly so, and curved circularly around the albu-



men, as in Goosefoot, Chickweed (Fig. 621), and *Mirabilis* (Fig. 616), it is said to be *peripheric*. When bent or folded in such a

FIG. 620. Campylotropous seed of the common Chickweed (*Stellaria media*), magnified.

FIG. 621. Section of the same, showing the embryo coiled around the outside of albumen.

FIG. 622. Vertical section of a grain of Indian Corn, passing through the embryo; c, the cotyledon; p, the plumule; r, the radicle. (A highly magnified portion of the albumen, which makes up the principal bulk of the grain, is shown in Fig. 70, p. 54.) 623. Similar section of a grain of Rice. 624. Vertical section of an Oat-grain: a, the albumen; c, the cotyledon; p, the plumule; and r, the radicle of the embryo.

way that the radicle lies along the edges of the cotyledons, the latter are said to be *accumbent* (Fig. 700); or when the radicle rests against the back of one of them, or in proximity to it (Fig. 705), they are *incumbent*.

640. The direction of the embryo with respect to the pericarp is also particularly noticed by systematic writers; who employ the terms *ascending*, or *radicle superior*, when the latter points to the apex of the fruit; *descending*, or *radicle inferior*, when it points to its base; *centripetal*, when the radicle is turned towards the axis of the fruit; *centrifugal*, when turned towards the sides; and *vague*, when it bears no evident or uniform relation of the kind to the pericarp.

641. As to the number of its cotyledons, or the degree of complexity or simplicity of the embryo, the principal types have already been considered (128). The plan of the embryo in Exogenous plants is to have a pair of opposite cotyledons; that is, the embryo is *dicotyledonous*, and such plants are denominated **DICOTYLEDONOUS PLANTS**.

642. A modification of this plan occurs in Pines and most other Coniferae, in which the cotyledons are increased to three, four, six, or even to fifteen, in a whorl (Fig. 133, 134); and this embryo of highest complexity is called *polycotyledonous*. The embryos of some Leguminous or Cruciferous plants are occasionally found, with three cotyledons, as an accidental deviation.

643. But in all Endogenous plants only one cotyledon appears, i. e. only one seed-leaf on the primary node; if two or more rudimentary leaves are present, they are alternate, and all but the first belong to the plumule. Here the embryo is *monocotyledonous*, and hence

Endogens are also termed **MONOCOTYLEDONOUS PLANTS**. The monocotyledonous embryo does not usually present a manifest distinction into radicle, cotyledons, and plumule, as the dicotyledonous; but often appears like a homogeneous and undivided cylindrical or club-shaped body, as in Iris



FIG. 625. Seed of *Triglochin palustre*; the raphe, leading to the strong chalazae at the summit, turned towards the eye. 626. The embryo detached from the seed-coats, showing the longitudinal chink at the base of the cotyledon; the short part below is the radicle. 627. Same, with the chink turned laterally, and half the cotyledon cut away, bringing to view the plumule concealed within. 628. A cross-section through the plumule, more magnified.

(Fig. 131) and *Triglochin* (Fig. 626). In the latter, however, close inspection reveals a vertical slit or chink just above the radicular extremity, through which the plumule is protruded in germination. If the embryo be divided parallel with this slit, the plumule is brought into view; as in Fig. 627. If a horizontal section be made at this point (as in Fig. 628), the cotyledon is found to be wrapped around the enclosed plumule, sheathing it, much as the bud and the younger parts of the stem are sheathed by the bases of the leaves in most monocotyledonous plants. The plumule is more manifest in Grasses, especially in the cereal grains, and more complex, exhibiting the rudiments of several concentric leaves, or of a strong bud, previous to germination (Fig. 622-624, and 126-128). In many cases, however, no distinction of parts is apparent until germination commences; as in the Onion, *Iris* (Fig. 131), &c.

644. In several Dicotyledonous plants one cotyledon is smaller than the other, viz. the inner one, when the embryo is coiled or folded. And in all the species of *Abronia* this cotyledon is wanting, so that the embryo becomes technically monocotyledonous. In the Dodder, a genus of leafless parasitic plants of the *Convolvulus* family, the embryo also is entirely destitute of cotyledons (Fig. 148). Here these organs are suppressed in an embryo of considerable size; but in most such parasites, the embryo is very minute, as well as reduced to the greatest degree of simplicity, and seems to remain until germination in a very rudimentary state.

645. Sometimes the two cotyledons of a dicotyledonous embryo are consolidated, or more or less coherent by their contiguous faces into one mass, when they are said to be *conferruminate*, as in the Horsechestnut, Buckeye (Fig. 629, 630), and the Chestnut. In these, as in other embryos with very thick cotyledons, the latter are

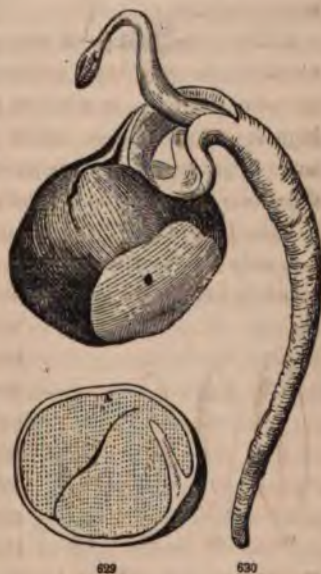


FIG. 629. Section of the seed of a Buckeye. 630. A Buckeye in germination.

necessarily *hypogæous* in germination (124, 126), that is, they remain underground, enclosed within the coats of the seed, yielding their abundant store of nourishment to the radicle and the plumule; and the first leaves that appear are those of the plumule.

SECT. II. GERMINATION.

646. Germination is the initial act of growth, by which the embryo in a seed develops into a plantlet. The steps of the early growth have already been sufficiently explained in an early part of this volume (119-132).

647. The seeds of some plants (such as the Red Maple) germinate shortly after falling to the ground; those of most other plants not until the next year, or even later. How long seeds may retain the power of germinating is uncertain, and is extremely variable in different species and families. Those of many plants under ordinary circumstances can rarely be made to grow after two or three years; some will germinate pretty well after several years keeping; and the seeds of certain Leguminous plants have been known to germinate when sixty years old. But the current accounts of wheat, &c. being raised from grain taken from ancient mummies, circumstantially authenticated as some of them appear to be, must be received with the greatest misgiving, if not with entire incredulity. One of the most probable cases of germination of ancient seeds on record is that given by Dr. Lindley, of some Raspberries, "raised in the garden of the Horticultural Society from seeds taken from the stomach of a man, whose skeleton was found thirty feet below the surface of the earth, at the bottom of a barrow which was opened near Dorchester. He had been buried with some coins of the Emperor Hadrian; and it is therefore probable that the seeds were sixteen or seventeen hundred years old." Most seeds, when buried deep in the soil, where they are subject to a uniform and moderate temperature, and removed from the influence of the air and light, may be in a favorable state for the preservation of vitality, and would be likely to germinate when brought to the surface after a considerable interval. But the possibility of mistake or of collusion must be more thoroughly eliminated before a case of such extraordinary tenacity of life, under conditions in some respects very unfavorable, can be considered as well established.

648. The conditions requisite to germination are exposure to moisture and to a certain amount of heat, varying from 50° to 80° (Fahrenheit) for the plants of temperate climates, to which must be added a free communication with the air. Direct light, so essential to subsequent vegetation, is unnecessary, and generally unfavorable, to germination. The degree of heat required to excite the latent vitality of the embryo is nearly uniform in the same species, but widely different in different plants; since the common Chickweed will germinate at a temperature not far above the freezing-point of water, while the seeds of many tropical plants require a heat of 90° to 110° (Fahrenheit) to call them into action, and are often exposed to a considerably higher temperature. Seeds are in the most favorable condition for germination in spring or summer, when loosely covered with soil, which excludes the light while it freely admits the air, moistened by showers, and warmed by the rays of the sun. The water which is slowly absorbed softens all parts of the seed; the embryo swells, and bursts its envelopes, or the elongating radicle is protruded from them, and all the parts grow or unfold in the manner already described, each organ in its proper medium, the root being developed in the soil, and the stem and leaves in the air. *Stellaria*

649. The nourishment which the embryo requires during germination is furnished by the starch, &c. of the albumen (632), when this substance is present in the seed; or by starchy or other nutritive matter accumulated in its own tissue (636, 123). But as starch is insoluble in cold water, certain chemical changes are necessary to bring it into a fluid state, so that it may nourish the embryo. These changes are incited by the proteine or neutral azotized products (354), which are largely accumulated in the seed, either in the albumen or in the embryo itself, and which take the initiative in all the transformations of vegetable matter (27). In the germinating seed, just as in growth from a bulb or tuber, the changes essentially consist in the transformation of the starch, first into dextrine, or gum, and thence into sugar, a part of which is destroyed by resolution, first into acetic acid, and finally into carbonic acid and water, with the abstraction of oxygen from the air, and the evolution of heat (349, 370-373), while the remainder is rendered directly subservient to the growth of the plantlet. The reason why light, so essential to subsequent growth, impedes or prevents incipient germination, becomes evident when we remember that it incites the

decomposition of carbonic acid, and the fixation of carbon by the plant (344-350); while germination is necessarily attended by an opposite transformation, namely, the destruction of a portion of organized matter, with the evolution of carbonic acid.* In germination, as in any other act in which matter is transformed or transferred, there is a certain expenditure of force and loss of organized material. The plantlet is obliged to decompose and destroy a part of the starch or other material provided for its initial growth, in order that it may transform the rest into dextrine and sugar, and this again into cellulose or the material of the new cells formed in its growth.

650. The study of the seed, and of the development of the embryo it contains into a plantlet, completes the cycle of vegetable life in the higher grade of Phænogamous plants, and brings us back to our starting-point (118, 119).

CHAPTER XII.

OF REPRODUCTION IN CRYPTOGAMOUS OR FLOWERLESS PLANTS.

651. THE lower grade of CRYPTOGAMOUS OR FLOWERLESS PLANTS (Chap. II. Sect. I.) would now require to be considered, both as to the vegetation and their reproduction. But the plan of structure in each principal Cryptogamous family is so peculiar, and the organs of fructification especially so diverse, that their morphology cannot be presented under one common type, as in Phænogamous vegetation. Each great family or group would have to be separately treated, and with much fulness of illustration, to make

* Seeds may casually germinate while attached to the parent plant, especially such as are surrounded with pulp, like those of the Cucumber and Melon. The process is liable to commence in wheat and other grain, when protracted warm and rainy weather occurs at the period of ripening; and the albumen becomes glutinous and sweet, from the partial transformation of the starch into dextrine and sugar. In the Mangrove, which forms dense thickets along tropical coasts, germination habitually commences in the pericarp while the fruit remains on the tree; and the radicle, piercing the integuments which enclose it, elongates in the air; such a plant being, as it were, *viviparous*.

the subject intelligible to the unpractised student. This can hardly be done in so elementary a work as the present, but requires a separate treatise. The student who has intelligently studied the present volume up to the present point, is prepared for the more difficult study of the structure of Cryptogamous plants, in the only general work of the kind that has yet appeared in the English language, viz. Berkeley's *Introduction to Cryptogamic Botany*. An enumeration of the Cryptogamous orders, with a brief notice of their structure and subordinate divisions, may be found in the systematic part of the present work. A slight sketch of their grades of development as to vegetation has already been given (97-113). We here attempt to present merely a very brief and general account of their plan of reproduction, divested as far as possible of technical terms.

652. Taken collectively, we distinguish this lower series of the vegetable kingdom by negative characters only; saying that these plants do not bear true *flowers* (consisting essentially of stamens and pistils), and accordingly do not produce *seeds*, or bodies consisting of a distinguishable embryo plantlet, developed in an ovule through fertilization by pollen. Their *spores* (97), or the bodies produced in their fructification by which they are propagated, and which therefore answer to seeds, are single cells, at least in most cases. These, as they germinate in the soil, or whatever medium they live in, undergo a development at the time of their germination which has been compared with that of the embryonal vesicle (579) during its development into the embryo in the ovule; and by growth directly give rise to the plant.

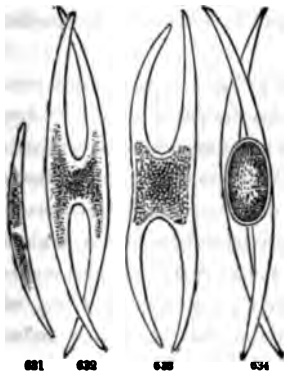
653. It was once thought probable, that these spores were produced, and were capable of developing into the plant without being fertilized by other cells answering to pollen; or at least that this was the case in all the lower orders, such as Algæ and Fungi, and in some of the highest, such as Ferns. But the sagacious Linnaeus, by naming them Cryptogamous plants (i. e. plants with concealed organs of reproduction) seems to have recorded his belief that they were really bisexual, or furnished with two sorts of organs, the fertilizing and the fertilized. A series of important discoveries, for the most part of recent date, have proved this to be so,—have made known a true fecundation in numerous species of every Cryptogamous order, and in their lowest as well as their highest forms, thus leaving no doubt of its universality. The apparatus and the processes of reproduction, however, are wonderfully varied in the different groups of Cryptogamous plants.

togamous plants. A few examples may be adduced, illustrative of the principal modes, beginning with the simplest plants.

654. **Reproduction in Plants of a Single Cell (100).** All such simple one-celled plants as *Protococcus* and the like (Fig. 79–83, 18–22), *Desmidiaceæ* and *Diatomaceæ*, are freely propagated by cell-multiplication (33–36),—the division of their protoplasm or whole living mass into bodies which directly become new cells like the parent,—or by original cell-formation in their interior (29). This is *non-sexual reproduction*, and essentially answers to the well-known propagation of *Phænogamous* plants by buds, bulbs, offsets, &c. It is probable that this may not go on indefinitely in any plant. At any rate, not only do all the higher plants propagate in a different way, viz. by flowers, producing seeds, but probably all plants of the lower grade also have a *sexual reproduction* in some form or other. It is certainly the case in many one-celled plants, and in others almost equally simple in structure. As in *Phænogamous* plants, sexual reproduction essentially depends upon the mingling of the materials of two distinct cells (as the pollen-cell and the embryonal vesicle, 579); and these cells in the lowest forms of vegetation represent individual plants. The simplest mode of such reproduction in the lowest plants, and that longest known, is what has been termed

655. **Conjugation.** This is the mode in which two vast tribes of microscopic one-celled aquatic plants, the *Desmidiaceæ* and *Diatomaceæ*, are reproduced. They *multi-*

ply rapidly, and apparently without limit, by successive division into two equal parts, which separate, each becoming like the original. But at length two of these individuals, being endowed with the power of movement, come into contact; the firm or often silicious cell-wall ruptures or gives way in a definite manner at the place of junction, and the whole contents of the two conjugating cells or individuals are commingled into one mass of

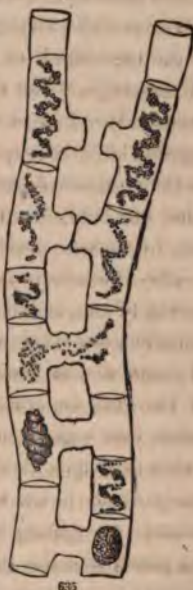


protoplasm, &c.; this soon has a coat of cellulose formed around it,

FIG. 631. Magnified individual of *Closterium acutum*, after Ralfs. 632. Two individuals more magnified, in conjugation; their cells opening one into the other, and the contents mingled; in 633, condensing; in 634, collected and formed into a spore.

and is now a spore, which when it grows begins a new series of individuals developed by successive division.

656. In Algae consisting of a Single Row of Cells one tribe presents the same mode of reproduction, and the various species of *Zygnema* or *Spirogyra*, found in almost every pool of fresh water at different times in spring and summer, afford the readiest illustrations of conjugation, which low powers of the microscope suffice to exhibit. These green threads when magnified are seen to consist of single rows of cylindrical cells joined end to end. The cells being all alike and equally capable of conjugation, each is as it were an individual. At a certain season, a protuberance appears on the corresponding parts of certain cells of two adjacent threads; the budding growth continues until the two come into contact; the intervening walls are then absorbed, opening a free communication between the cavities of the two cells; meanwhile the green matter and protoplasm, before arranged in some definite shape in each species (more commonly in one or more spiral bands), break up into a granular mass floating in the water of the cell; this all passes over from one



cell to the other, — sometimes to the one plant and sometimes to the other in adjacent cells, — and is mingled with the similar contents of the cell which receives it; and the united product is condensed into a green protoplasmic mass, which, acquiring a coat of cellulose, becomes a new cell or spore, in due time germinating into a new plant.

657. In reproduction by conjugation, the two cells or individuals concerned are alike; one is as much the fertilizer or the fertilized as the other. But the clear distinction of sexes which all the higher Cryptogamous no less than Phanogamous plants exhibit, is also manifested in those of the simplest structure, viz. in plants consisting of single cells, or of rows or clusters of similar and essentially independent cells. That is, even these afford examples of

FIG. 635. Magnified view of two conjugating filaments of *Zygnema*, showing all the stages of the process by which the cells from two filaments form each a corresponding protuberance, these come into contact, the intervening walls are absorbed, and the contents pass from one cell into the other, condense, acquire an investing membrane, and so form a spore: the stages are represented from above downwards; a completed spore is seen at the bottom, on the right.

658. Direct Fertilization of Spores by Spermatozoids from an Antheridium; the latter answering to the anther, or essential part of the stamen, of Phænogamous plants. Cohn* has shown that even Volvox — an undoubted vegetable, consisting of microscopic one-celled plants of rounded form, grouped into a spherical colony — has a true sexual propagation, like that of the higher green Algae, some of the individuals or cells of the sphere producing *antheridia* or fertilizing cells, while others produce spores, or bodies which become such on being fertilized by the antheridia, which alone renders them capable of germination. A good general idea of bisexual reproduction in the simplest Algae may best be obtained from a brief abstract of what has lately been discovered by Pringsheim and Cohn in two or three common species of comparatively easy investigation.

659. Vaucheria is a genus of several species of green Algae, consisting of simple but indefinitely branching cells (Fig. 89). In fructification, the whole contents of the more or less enlarged extremity of some of the branches, or of a special projection from the side of the cell, separate from the general contents of the plant, condense into a globular green mass (Fig. 89 a), and become a spore, which at length escapes by a rupture of the walls (Fig. 90), moves freely about in the water for some hours, then fixes itself, and germinates, elongating directly into a thread-like and at length branching plant, like the parent. Here there appears, and was generally thought to be, reproduction without fecundation. Vaucher, however, more than half a century ago, noticed one or more horn-shaped projections in the vicinity of the spore-bearing portion, which he suspected to be the analogues of the anther. Nothing had been found to verify this view until the year 1854, when Pringsheim, of Berlin, discovered the fecundation and verified this conjecture. The horn-shaped body is an *antheridium*, or the analogue of the anther. It produces myriads of extremely minute corpuseles, of oblong shape, and furnished with a bristle or cilia at each end, by the vibration of which they move freely in the water. These are *spermatozoids* (so called from their obvious resemblance to the spermatozoa of animals), and the analogues of pollen. At the proper time the antheridium bursts at the summit, and discharges the spermatozoids; at this time the wall of the projection which contains the spore likewise opens; numbers of the free-moving spermatozoids find their way

* In *Comptes Rendus*, vol. 43, 1856, and *Ann. Sci. Nat.* ser. 4, vol. 5, p. 323-

into the opening and into contact with the forming spore, or even penetrate its substance; it being an amorphous mass, coated with protoplasm only. But, as a consequence of fecundation by one or more spermatozoids, a wall of cellulose is presently formed on its surface, converting it into a proper specialized cell or spore.*

660. *Ædogonium* is a genus of simple Algæ of the *Conferva* tribe, consisting of a row of cylindrical cells placed end to end, as in Fig. 639. Some of these cells, usually shorter than the rest, become tumid, and, without conjugation, have their whole green contents transformed into a spore resembling that of *Zygnema* (Fig. 635) and *Vaucheria* (Fig. 90). The fertilization of this spore has recently been discovered by Pringsheim.† He ascertained that other cells of the same little plant produce a great number of minute ovoid bodies, which he names *Androspores*: these escape by the opening of the mother cell, moving about freely by the vibration of a crown of cilia attached near the smaller end. One or more of these androspores fix themselves by the smaller end upon the surface of the cell in which a large ordinary spore is forming, or in the vicinity, and germinate there, growing longer and narrower at the point of attachment, while near the free end a cross partition forms, and sometimes another, making one or two small cells; this is the true antheridium; for in it a crowd of spermatozoids are formed, also endowed with motivity by means of vibratile cilia. Now the top of the antheridium falls off as a lid, the spermatozoids escape; the spore-cell at this time opens at the top; one of the spermatozoids enters the opening, its pointed end foremost; this becomes stationary upon or slightly penetrates the surface of the young spore, into which its contents are probably transferred, by rupture or by endosmosis, and a coat of cellulose is then, but not till then, deposited upon it, completing its organization as a spore. This spore, as in the preceding cases, in due time germinates, and grows directly into a plant like the parent. But in *Bolbochaete*, according to Pringsheim, and in *Sphæroplea*, as investigated by Cohn,‡ the spore in germination converts its contents by successive division into a large number of small, oval or oblong bodies, furnished with two long cilia on a short

* Pringsheim, in the Proceedings of the Royal Academy of Sciences, Berlin, March, 1855, and *Ann. Sci. Nat.* ser. 4, vol. 3, p. 363.

† *Op. supra cit.* May, 1856, and *Ann. Sci. Nat.* ser. 4, vol. 5, p. 250.

‡ *Op. supra cit.* May, 1855, and *Ann. Sci. Nat.* l. c. p. 186, pl. 12, 13.

beak at one end, and which from their extreme resemblance to animalcules and their lively movements are called *Zoöspores*. And these zoöspores germinate by elongation and the formation of transverse partitions into adult thread-like plants, consisting of a row of cells. The whole contents of the cells of some adult individuals of *Sphæroplea* are formed into large green spores, as yet without a coat; those of different individuals give rise to myriads of slender spermatozoids, moving by means of a pair of cilia fixed at the narrow end. These escape from the parent cell through a small perforation which now appears, enter the spore-bearing cells of the fertile plant through a similar perforation, play around the spores, and at length one or more of them drives its pointed extremity into their naked surface; after which, fertilization being accomplished, a thick coat of cellulose is deposited to complete the spore.

661. That in the *Fucaceæ* or olive-green Seaweeds, the highest tribe of *Algæ*, the large spores are fecundated by spermatozoids, or minute lively-moving cells produced in antheridia, was demonstrated by Thuret in the year 1850.* And in more recent memoirs † he has shown that the fertilization takes place through direct contact of the spermatozoids with the naked surface of the unimpregnated spore, then having only a protoplasmic coating; and that these spores will not develop unless so fertilized. Through the researches of Thuret and others, antheridia are now well known in the remaining or rose-red series of *Algæ*, although their spermatozoids are not known to be endowed with motivity. The same appears to be the case with Lichens, the bodies described by Itsigsohn,‡ being probably of the nature of spermatozoids or fertilizing cells. In the vast family of Fungi there are similar indications of antheridia and spermatozoids, but the fecundation is not yet clearly made out.

662. **Fertilization by Spermatozoids of a Cell in a Pistillidium, which becomes a Sporangium.** In all the foregoing cases, the spores themselves are the subjects of direct fertilization. But in Mosses, Liverworts, &c. (in which the two kinds of organs have long been recognized and their functions to some extent understood), the contents of the antheridium act upon an organ which, in conse-

* *Ann. Sci. Nat.* ser. 3, vol. 14 and 16, 1850-1. See Harvey, *Nereis Bor.-Amer.* in *Smithsonian Contributions*, 1852, &c.

† *Op. cit.* ser. 4, vol. 2 and 3, 1854, 1855.

‡ In *Botanische Zeitung*, 1850.

quence of fertilization, develops into a sort of pod, the *Sporangium* or *Spore-case*, filled with a multitude of spores which receive no individual fecundation; this organ, from its general analogy to the pistil, has been termed a *Pistillidium*. The antheridia of Mosses and the like occur either in the axils of the leaves, or collected into a head at the summit of the stem. They are found either in the same heads as the pistillidia, or in distinct heads on the same individuals (monœcious), or on separate individuals (diœcious). The antheridium (Fig. 1307) is merely a cylindrical or club-shaped sac, composed of a single layer of cells, united to form a delicate membrane; within which are developed vast numbers of minute, very delicate cells, completely filling the sac. The sac bursting at its apex when mature, the delicate vesicles are discharged. Each of these contains a slender filament, thickened at one end and tapering off to a fine point at the other: it may be seen through the transparent walls, spirally coiled up in the interior of each vesicle. When these vesicles are extruded in water under the microscope, the contained filaments may be seen to execute lively movements, wheeling round and round in the vesicle, or, when disengaged from the latter, and assuming a corkscrew form, at the same time advancing forward, the thin end of the filament almost always preceding. Minute observation, which is very difficult, both from the rapidity of the motion (which, however, is arrested by poisons) and from the great delicacy of the whole structure, shows that the movements arise from two long and extremely delicate cilia, attached to the tapering end of the filament. These are the spermatozoids, or true fertilizing organs. The pistillidia (Fig. 1306), which appear at the same time as the antheridia, and often mixed with them, are flask-shaped bodies (like an ovary in shape), with a long neck (resembling a style), composed of a cellular membrane. The neck is perforated by an open canal, leading to a cavity below, at the base of which a single cell is the germ of the future *sporangium* or *spore-case*. Upon this the spermatozoids, or spiral filaments of the antheridia, act, one or more of them reaching it by finding their way down the canal of the pistillidium. Then this cell commences a special development, divides into two, and proceeds by ordinary cell-multiplication to build up the sporangium or capsule, in which a countless number of minute spores are produced. The spores of Mosses are formed in the same way as pollen-grains, which they much resemble in structure, being single cells with a double coat, of

which the inner is the true cell-wall, and the outer a sort of secretion from it. In germination, the inner or proper membrane of the spore swells, and protrudes, from any part of its surface favorably situated, a tubular process, which forms partitions as it elongates and branches, giving rise to what has been fancifully named a *pro-embryo*, or, better, a *prothallus*, — a rudimentary plantlet very unlike a Moss, but closely resembling a branched Conferva, consisting, as it does, merely of ramified threads, or rows of cells. After a time certain cells of its various branches, taking a special development, produce buds, which are soon covered with a tuft of rudimentary leaves, and grow up into the leafy stems of the perfected plant. Here a single spore — or rather a peculiar transitory plantlet developed from it — gives rise at once to a number of individuals. And in fecundation it is not the spores themselves that are fertilized, but a cell which by its development gives origin to a spore-case, and this to a vast number of spores.*

663. Fertilization of a Cell of a Prothallus, or peculiar germinating Plantlet, which thereupon develops into a Plant. This most extraordinary mode of fecundation has recently been discovered in the Ferns and other of the higher Cryptogamous orders. The fructification of Ferns consists of spore-cases alone, which are borne on the back, margins, or some other part of their leaves (Fig. 1287–1294), and are filled with spores resembling those of Mosses. Since Mosses have long been known to have organs answering in function to stamens, as well as those answering to pistils, and since Ferns are regarded as plants of higher rank than Mosses, their antheridia were diligently sought for upon the fructifying plants, but in vain; and botanists were therefore forced to the unwilling conclusion, that the highest organized of Cryptogamous plants were asexual. But antheridia, essentially like those of Mosses, have been at length detected, not upon the mature and fructifying plant, but upon the germinating plantlet. The germination of the spores of Ferns had long since been observed. The process begins in the same manner as in Mosses; but the extremity of the tubular prolongation of the spore, converted by partitions into a row of cells, is developed into an expanded, leaf-like body (the *pro-embryo*, or *prothallus* as it is now called), which

* The fullest account is by Hofmeister, *Vergleichende Untersuchungen der Keimung, Entfaltung, und Fruchtbildung Höherer Kryptogamen*, etc. — Leipsic, 1851.

on a small scale resembles a frondose Liverwort. Upon this body, Nägeli, in 1844, found moving spiral filaments, like those of the antheridia of Mosses, &c. This, as Henfrey remarks, "seemed to destroy all grounds for the assumption of distinct sexes, not only in the Ferns, but in the other Cryptogamia; for it was argued that the existence of these cellular organs producing moving spiral filaments (the so-called spermatozoa) upon the germinating fronds, proved that they were not to be regarded as in any way connected with the reproductive processes. But an essay published by the Count Suminski in 1848 totally changed the face of the question." On the under side of the delicate, Marchantia-like, germinating frond, Suminski found a number of cellular organs of two distinct kinds, answering to antheridia and pistillidia. The former, which are the more numerous, are cells elevated on the surface of the germinating frond, in the cavity of which are formed other cells, filled with minute vesicles containing each a spiral filament coiled up in its interior. The organ bursts at its summit, and discharges the vesicles in a mucilaginous mass; the spiral filaments moving within the vesicles at length make their way out of them and swim about in the water. These filaments, or spermatozoids, resemble those of Mosses, but are flat and ribbon-like, as in Chara, and possess according to Suminski about six, according to Thuret numerous cilia, by whose vibrations they are moved. The pistillidia, if they may be so called, are rounded cavities in the cellular tissue of the same body, opening on the under side, in the bottom of which is a single globular cell, from which the future growth proceeds. One or more of the active spermatic filaments, liberated by the bursting of the antheridia, have been found to enter the open pistillidium, and to come to rest and then wither away in contact with this specialized cell. The latter now develops into a *bud*, or embryo, as it may perhaps be termed, which grows in the ordinary way, producing an abbreviated axis, sending roots downward and leaf after leaf upwards; and so producing the mature Fern.* And, as most Ferns are perennial plants, they produce year after year their fructification (consisting

* The English reader is referred to Henfrey's Translation of Mohl's *Anatomy and Physiology of the Vegetable Cell*; and Henfrey's *Report on the Reproduction and supposed Existence of Sexual Organs in the higher Cryptogamous Plants*, in the Report of the British Association for the Advancement of Science, for 1851, reprinted in Silliman's Journal, Vol. 14 and 15; from which the above account has been condensed.

merely of spores in spore-cases), without any known limit, and without any other fecundation than that which occurred at first upon the germinating plantlet.

654. In Ferns, accordingly, it is not the sporangium that is fertilized, still less the spores, but a cell of a peculiar transitory plantlet formed by the germination of a spore. This cell otherwise will not develop at all; but when thus fecundated, it develops like a bud, and grows into a plant of indefinite longevity, capable of fructifying by a true *parthenogenesis* (571) throughout its long existence. This is also known to be the case with Equisetaceæ; and the Lycopodiaceæ or Club-Mosses and other vascular Cryptogamous Plants are thought to have analogous fecundation, although the details as yet are not well made out.

CHAPTER XIII.

OF THE SPONTANEOUS MOVEMENTS AND VITALITY OF PLANTS.

665. THE facts brought to view in the preceding chapter, namely, that either the spores or the fertilizing corpuscles or filaments of most Cryptogamous plants of every order are temporarily endowed with motivity, naturally raises the inquiry whether such phenomena are altogether exceptional in the vegetable kingdom, or whether the power of executing movements is not a general endowment of plants as well as of animals, although in lesser degree. As we pass in review the various phenomena exhibited by plants in this respect, and at the same time consider that self-caused motion, internal or external, or the faculty of directing motion, is a necessary concomitant of life, we shall probably arrive at the conclusion, that this surprising activity of the microscopic spores and spermatozoids of Cryptogamous plants is not altogether anomalous,—that these are merely more vivid manifestations of a power which they share with ordinary vegetables,—that plants are endowed with life no less really than animals,—that the distinction between plants and the lower animals in respect is one of degree rather than of kind,—and that it is a characteristic of living things to move.

666. The Special Directions which the parts of all plants assume are the result of self-caused movements, although such movements are mostly much too slow to be directly observed. Among these the most universal are the descent of the root in germination, the ascent of the stem into the light and air, and the turning of branches and the upper surface of leaves towards the light (120, 131, 294). These directions evidently are not the result of mere growth. It is not that the root grows downwards and the stem upwards; but the root end of the elongating radicle bends or curves in the course of its growth so as to point downwards if not already in that position, and the other extremity, with the plumule, curves upwards, and the young stem, after reaching the light, if unequally illuminated, bends towards the stronger light.

667. Strenuous attempts have been made to explain these changes of direction upon mechanical principles. Mr. Knight thought that the descent of the root and the ascent of the stem were caused by gravitation; and he seemed to show this by his celebrated experiments of removing germinating seeds from the influence of gravitation, and causing the root and stem to take a different direction in obedience to a different force. He fixed some beans ready to germinate in a quantity of moss upon the circumference of a wheel, and made it to revolve vertically at a rapid rate; replacing the effect of gravity by centrifugal force. On examination, after some days, the young root was found to have turned towards the circumference, and the stem towards the centre of the wheel. The same result took place when the wheel was made to revolve horizontally with considerable rapidity; but when the velocity was moderate, the roots were directed obliquely downwards and outwards, and the stems obliquely upwards and inwards, in obedience both to the centrifugal force and the power of gravitation, acting at right angles to each other. It remained for Mr. Knight to explain how the same force, gravitation, could produce such opposite effects, causing the stem to ascend as well as the root to descend. This he ingeniously attributed to their different mode of growth. The root growing at its extremity only, he supposed that the soft substance of the growing point would be acted upon by gravity like an imperfect solid, and accumulated on the lower side; while the stem, growing by the elongation of an internode or a series of internodes already formed, its solid tissues would be unaffected by gravity, which could affect only its nutritive juices, causing their accumulation on the lower side of a

stem out of the perpendicular line ; which side, thus more actively nourished, would grow more vigorously than the upper, and so cause the stem to turn upwards. To show how baseless this ingenious hypothesis is, we have only to remember, on the one hand, that the fluid contents of the cells of plants arrange themselves in obedience to other forces than gravity, and freely rise against its influence to the summit of the loftiest trees, so that gravity could establish no difference within the diameter of a germinating stem ; and on the other, that the root in germination, if fixed upon its surface, will penetrate a fluid of greater weight than itself, such as mercury. Moreover, Schultz and Mohl have shown that, by careful management in reversing the ordinary conditions, — as by germinating seeds in damp moss, so arranged that the only light they could receive was reflected from a mirror, which threw the solar rays upon them directly from below, — the ordinary direction of the organs could be reversed, the roots turning upwards into the dark and damp moss, and the stems downward into the light. This would prove that light has more effect than gravitation, or any other imaginable influence of the mass of the earth. Yet, — what shows that there is some real relation between the direction assumed by the plant and the earth, — stems which grow in complete darkness always point to the zenith, as is seen in the shoots of vegetables in perfectly dark cellars, and in the elongated, constantly upright stemlet of germinating seeds too deeply buried to receive any light before they reach the surface of the soil.

668. The influence of a mass in some way analogous to attraction is also observed in the germination of the Mistletoe. Its forming root turns regularly to the trunk or branch upon which it is parasitic, just as those of ordinary plants turn to the earth. And that it is the mass and not the quality of the body which determines the direction, is seen when germinating seeds of the Mistletoe are fixed close to the surface of a cannon-ball : all the roots as they grow point to its centre and advance to its surface, just as they do to the branch of a tree which they penetrate.

669. When the stem has emerged from the earth into the light of day, this exerts a controlling influence over its direction. Young and green stems always tend to expose themselves as much as possible to the light, and bend, very promptly when delicate, towards the most illuminated side, as is well observed when plants are raised in an apartment lighted from a single aperture : and consequently in the open air, being equally illuminated on all sides, they grow up-

right. De Candolle attempted a mechanical explanation of this bending of green stems towards the light, connecting it with assimilation and growth. He supposed that, as the side upon which the light strikes will fix most carbon by the decomposition of carbonic acid (346-348), so its tissue will solidify faster, and therefore elongate less, than the shaded side (which will become *drawn*, as the gardener terms it); and the stem or branch will necessarily bend towards the shorter or illuminated side. But when the light is equally diffused around a plant, the decomposition of carbonic acid will take place uniformly on all sides, and the perpendicular direction naturally be maintained. Two facts at once demolish this ingenious theory. 1. It is now well known that, under the solar spectrum, the decomposition of carbonic acid in the green parts of plants is effected chiefly by the most luminous rays, that is, by yellow light, and next to this by orange and red; whereas the bending is strongest under the violet and blue rays, the yellow producing little curvature, and the red none at all. 2. When a stem curved under the light is split from the apex downwards, so as to separate the illuminated from the shaded side, the former curves more than before, while the latter tends to straighten,—showing that it was pulled over by the contraction of the concave side, and not pushed over by its own greater growth. From all this it clearly appears that the turning of parts towards the light, and the other special directions of plants, are independent of growth, and apparently are effected by some inherent power. At least, they have thus far proved no more susceptible of mechanical explanation than the more marked movements of animals.

670. In leaves it is the denser and deeper green upper surface (262) that is presented to the light, while the paler lower surface, of looser tissue, avoids it. The recovery of the natural position, when the leaf is artificially reversed, is the more promptly effected in proportion to the difference in structure and hue between the two strata. This movement is so prompt in some plants, that their leaves follow the daily course of the sun. The leaf is more capable of executing such movements, on account of its extended surface, and its pliancy, and also on account of its usual attachment by an articulation. Here the slender vascular bundles oppose little resistance to lateral motion, while the soft and usually cellular enlargement favors it. Indeed, the efficient cause of the movement appears to be exerted here, and to be connected with the unequal tension or turgescence of

the cells on the two sides. We might therefore expect more prompt and obvious changes of position in leaves than in stems. Familiar examples of the kind are met with in the altered nocturnal position of the leaves, &c. of many plants (often drooping, or folded as if in repose), which Linnaeus designated by the fanciful name of

671. *The Sleep of Plants.* This is well seen in the foliage of the Locust and of most Leguminous plants, and in those of Oxalis, or Wood-Sorrel. It is most striking in the leaflets of compound leaves. The nocturnal position is various in different species, but uniform in the same species, showing that the phenomenon is not mechanical. Nor is it a passive state, for, instead of drooping, as do those of the common Locust-tree, the leaflets are very commonly turned upwards, as those of Honey-Locust, or upwards and forwards, as in the Sensitive-Plant, contrary to the position into which they would fall from their own weight. De Candolle found that most plants could be made to acknowledge an artificial day and night, by keeping them in darkness during the day, and by illuminating artificially at night. The sensibility to light appears to reside in the petiole, and not in the blade of the leaf or leaflet; for these movements are similarly executed, when nearly the whole surface of the latter is cut away.

672. The leaves of the blossom also assume various positions, according to the intensity and duration of the light. Many expand their blossoms in the morning and close them towards evening, never to be opened again, as those of Cistus, Portulaca, and Spider-wort; while others, like the Crocus, close when the sun is withdrawn, but expand again the following morning. On the other hand, the Evening Primrose, *Silene noctiflora*, &c. unfold their petals at twilight, and close at sunrise. The White Water-Lily (*Nymphaea*) expands in the full light of day, but uniformly closes near the middle of the afternoon, and is then usually withdrawn beneath the surface of the water. The Morning-Glory opens at the dawn; the Lettuce, and most Cichoraceous plants, a few hours later, but close under the noonday sun; the *Mirabilis* is called Four-o'clock, because opening nearly at that hour in the afternoon, and it closes the next morning; and so of other species,—each having its own hour or amount of light in which its blossoms open or close. Berthelot mentions an *Acacia* at Teneriffe, whose leaflets regularly close at sunset and unfold at sunrise, while its flowers close at sunrise and unfold at sunset. Although these movements, both in leaves and blossoms, are undoubtedly dependent on the light, they are by no means directly

governed by it. The so-called sleep of the common Sensitive Plant, for instance, begins just before sunset, but its waking frequently precedes the dawn of day; showing that it is not the mere amount of the light which governs the position, in the manner of a mechanical power.*

673. *Sensible Movements from Irritation.* All the changes of position already described—like those of the hands of a clock or of the shadow on a dial—are too slow for the motion to be directly seen. But a greater exaltation apparently of this common faculty is observed in the leaflets of various Leguminous plants, especially of the *Mimosa* tribe, which, when roughly touched, assume their peculiar nocturnal position, or one like it, by a visible and sometimes a rapid movement. The Sensitive Plant of the gardens (*Mimosa pudica*) is a familiar instance of the kind, suddenly changing the position of its leaflets on being touched or jarred, and applying them one over the other close upon the secondary petiole; if more strongly irritated, the secondary petioles also bend forward and approach each other, and the general petiole itself sinks by a bending at the articulation with the stem. Similar although less vivid irritability is shown by the *Mimosa strigillosa* and the *Schrankia* of the Southern States, where the leaflets promptly fold up when brushed with the hand. The most remarkable instance of the kind, however, is presented by another native plant of the United States, the *Dionæa muscipula*, or Venus's Fly-trap (Fig. 297, 298); in which the touch even of an insect, alighting upon the upper surface of the outspread lamina, causes its sides to close suddenly, the strong bristles of the marginal fringe crossing each other like the teeth of a steel-trap, and the two surfaces pressing together with considerable force, so as to retain, if not to destroy, the intruder, whose struggles only increase the pressure which this animated trap exerts. This most extraordinary plant abounds in the damp, sandy savannas in the neighborhood of Cape Fear River, from Wilmington to Fayette-

* The odors of flowers, also, are sometimes given off continually, as in the Orange and the Violet, or flowers may nearly lose their fragrance during the heat of mid-day, as in most cases; while others, such as *Pelargonium triste*, *Hesperis tristis*, and most dingy flowers, which are almost scentless during the day, exhale a powerful fragrance at night. The night-flowering *Cereus grandiflorus* emits its powerful fragrance at intervals; sudden emanations of odor being given off about every quarter of an hour, during the brief period of the expansion of the flower.

ville, North Carolina, where it is exceedingly abundant; but it is not elsewhere found.

674. A familiar, although less striking, instance of the same kind is seen in the stamens of the common Barberry, which are so excitable, that the filament approaches the pistil with a sudden jerk, when touched with a point, or brushed by an insect, near the base on the inner side. The object of this motion seems plainly to be the dislodgement of the pollen from the cells of the anther, and its projection upon the stigma. But in the *Dionæa* it is difficult to conceive what end is subserved by the capture of insects. In a species of *Stylidium* of New Holland, not uncommon in conservatories, the column, consisting of the united stamens and styles, is bent over to one side of the corolla; but if slightly irritated, it instantly springs over to the opposite side of the flower. These are among the more remarkable cases of the kind, but by no means the only ones. Anatomical investigation brings to view no peculiarity in the structure of such plants which might explain these movements. Some other movements, which have been likened to these, are entirely mechanical; as that of the stamens of *Kalmia*, where the ten anthers are in the bud received into as many pouches of the monopetalous corolla, and are carried outwards and downwards when the corolla expands. In this way the slender filaments are strongly recurved, like so many springs; until at length, when the anthers are liberated by the full expansion of the corolla, or by the touch of a large insect or other extraneous body, they fly upwards elastically, projecting a mass of pollen in the direction of the stigma.

675. The twining of stems round a support, and the coiling of tendrils, are attributed by Mohl to a dull irritability; and this is the most plausible explanation that has been offered. The inner side, which becomes concave and has smaller cells, is in this, as in other cases, the irritable portion. When a foreign body is reached, a contraction of this side causes the tendril partially to embrace the support: this brings the portion just above into contact with it, which is in like manner incited to curve; and so the hold is secured, or the twining stem continues to wind around the support. In tendrils this irritability, propagated downward along the concave side, would appear to cause its contraction, which throws the whole into a spiral coil, or, when fixed at both ends, into two opposite spiral coils, thus approximating the growing stem to the supporting body.

676. In all these cases, whether of slow or rapid change of position, the immediate cause of the movement, however incited, must be either the shortening of the cells on the concave side, or their elongation on the convex side. The fact that stems curved towards the light tend to curve still more when the convex side is cut away (669) points to a contraction of the cells on the concave side as the cause of the curvature. The elastically bursting pods of the Balsam or Touch-me-not (*Impatiens*), &c. confirm this view. Here the valves of the capsule curve inwards very strongly when liberated in dehiscence; and that this is owing to the shortening of the cells of the inner layer, and not to the enlargement or turgescence of those of the thick outer layer, is readily shown by gently paring away the whole outer portion before dehiscence; for the inner layer when liberated still incurves and rolls itself up as strongly as before. The short valves at the summit of the pod of *Echinocystis* slowly curve outwards in dehiscence; here the cells of the outer layer of the valve are longer and narrower than those of the inner, and the latter are stretched and torn in opening; so that here the contraction of the cells on the side which becomes concave is undoubtedly the cause of the movement. And since muscular movements are effected by the contraction of the cells which, placed end to end, compose a muscular fibril, we may suspect that vital movements generally, both in vegetables and in animals, are so far analogous, that they are brought about in the same general way, viz. by the shortening of cells. Even the opening and closing of the stomata of the leaves (268) appear to be controlled by the vital force, and to be effected by a self-caused change in the form of the guardian cells. How the light, or external irritation, or any other influence, acts in inciting this change of form of the cells of some part of a plant, we know no more, and no less, than we know how a nerve, or an electrical current, acts upon a muscle of an animal to bring about the contraction or change of shape of its component cells. If animals make

677. *Spontaneous or Automatic Movements*, so also do some plants execute brisk and repeated movements irrespective of extraneous force, or even of extraneous excitation, and which, indeed, are arrested by the touch. An instance of such spontaneous and continued motion, of the most remarkable kind, is furnished by the trifoliate leaves of *Desmodium gyrans*, an East-Indian Leguminous plant. The terminal leaflet does not move, except to change from the

diurnal to the nocturnal position, and the contrary; but the lateral ones are continually rising and falling, both day and night, by a succession of little jerks, like the second-hand of a time-keeper; the one rising while the other falls. Exposure to cold, or cold water poured upon the plant, stops the motion, which is immediately renewed by warmth. The late Dr. Baldwin is said by Nuttall to have witnessed the same thing in our own *Desmodium cuspidatum*, in Georgia; but the observation has never been confirmed. In several tropical Orchideous plants, and especially in a species of *Megacelinium*, the lower petal, or *labellum*, executes similar spontaneous movements, with great freedom and pertinacity. Such phenomena, occurring as they do in Phanogamous plants of ordinary structure may serve to render more credible the true vegetable character of the

678. Free Movements of the Spores of Algæ, and the corpuscles or spiral filaments of the antheridia of most Cryptogamous plants, already referred to (659-663). The spores of most of the lower Algæ are now known to exhibit this peculiar activity at the time of their discharge from the parent cell, when, for some moments, or usually for several hours, they behave like infusory animals, executing spontaneous movements in the water, until they are about to germinate. This singular movement was first detected many years ago in *Vaucheria*



FIG. 636. Fruiting end of a plant of *Vaucheria geminata* (after Thuret); one of the branches still containing its spore. 637. Moving spore just escaped from the apex of the other branch; the ciliary apparatus seen over the whole surface. 638. Spore in germination.

FIG. 639-642. Successive steps in the germination of *Edogonium* (*Conferva*) *volens*. 643. The plant developed into a series of cells, four of which display the successive steps in the formation of a spore. 644. The locomotive spore with its vibratile cilia (copied from Thuret). When the movement ceases, and it begins to germinate, it appears as in 639. (The antheridia or fertilizing apparatus of these plants were not known when these figures were made.)

(Fig. 89, 636). Immediately on its discharge from the mother plant the spore begins to move freely in the water, and continues to do so for some hours, when it fixes itself and begins to grow (Fig. 638). Its movements, moreover, like those of the antheridial filaments or corpuscles, may be enfeebled or arrested by the application of a weak solution of opium or chloroform. Through these means it has been ascertained that they are caused by the vibrations of minute cilia which cover the surface, which are rendered visible by thus enfeebling their movement, and which exhibit the closest resemblance to the vibratile cilia of animals, especially those of the polygastric animalcules. In the *Conferva* tribe generally the vibratile cilia occupy one end of the spore, and are in some cases numerous (as in Fig. 644), in others only two or three in number. The spores are small, and of about the same specific gravity as the water in which they live, so that a slight force suffices to propel them.

679. *Locomotion of Adult Microscopic Plants.* The spores of *Vaucheria* and the like, becoming quiescent before germination, grow into fixed thread-like plants of considerable size, endowed with no greater degree of motivity than ordinary vegetables. A multitude of still simpler *Algæ*, however, swarm in every pool or stream, so minute in size as to be individually totally invisible to the naked eye (most of them when full grown are very much smaller than the spores of *Vaucheria*, &c.); and these are endowed, even at maturity, with such powers of locomotion that their vegetable character, although now well made out, was long in question on this account alone. Of this kind are the various species of *Oscillaria* (Fig. 84), so named from the writhing movement they exhibit, the *Desmidiaceæ*, to which *Closterium* (Fig. 631) belongs, and the nearly allied *Diatomaceæ*,—the lowest, minutest, and the most freely moving of plants, but clearly members of the vegetable kingdom notwithstanding. These execute free movements of translation, in some cases slow, in others rapid; but the mechanism of the motion is still unknown.

680. Not only, therefore, do plants generally manifest impressibility or *sensitiveness* to external agents, and execute more or less decided, though slow, movements; but many species of the higher grades exhibit certain vivid motions, either spontaneous or in consequence of extraneous irritation; while the lowest tribes of aquatic plants, as they diminish in size and in complexity of organization, habitually execute, at some period at least, varied spontaneous move-

ments, which we are unable to distinguish in character from those of the lowest animals. It is at their lowest confines, accordingly, that the vegetable and the animal kingdoms approach or meet, and even seem to blend their characters.

681. When we consider that the excitability of sensitive plants is often transmitted, as if by a sort of sympathy, from one part to another; that it is soon exhausted by repeated excitation (as is certainly the case in *Dionaea*, the Sensitive-Plant, &c.), to be renewed only after a period of repose; that all plants require a season of repose; that they consume their products and evolve heat under special circumstances with the same results as in the animal kingdom (Chap. VII.); that, as if by a kind of instinct, the various organs of the vegetable assume the positions or the directions most favorable to the proper exercise of their functions and the supply of their wants, to this end surmounting intervening obstacles; when we consider in this connection the still more striking cases of spontaneous motion that the lower *Algæ* exhibit; and that all these motions are arrested by narcotics, or other poisons, — the narcotic and acrid poisons even producing effects upon vegetables respectively analogous to their different effects upon the animal economy; we cannot avoid attributing to plants a vitality and a power of "making movements tending to a determinate end," not different in nature, perhaps, from those of the lowest animals. Probably life is essentially the same in the two kingdoms; and to vegetable life faculties are superadded in the lower animals, some of which are here and there not indistinctly foreshadowed in plants.

682. The essential differences between plants and animals were enumerated at the commencement of this work (16), and have been illustrated in its progress. Distinct as are the general structure and the offices of the two great kinds of organized beings, it is still doubtful whether the discrimination is absolute, or whether the functions of the vegetable and the animal may not, in some microscopic organisms, be imposed upon the same individual.

PART II.

SYSTEMATIC BOTANY.

683. In the preceding chapters plants have been considered in view of their structure and action. And when different plants have been referred to and their diversities noticed, it has been in elucidation of their morphology,—of the exuberantly varied forms or modifications under which the simple common plan of vegetation is worked out, as it were, in rich detail. The vegetable kingdom, that is, vegetation taken as a great whole, presents to our view an immense number of different kinds of plants, more or less resembling each other, more or less nearly related to each other. It is the object of SYSTEMATIC BOTANY to treat of plants as members of a system, or orderly parts of a whole,—and therefore to consider them *as to their kinds*, marked by differences and resemblances, and to contemplate the relations which the kinds, or individual members of the great whole, sustain to each other. To this end the botanist classifies them, so as to exhibit their relationships, or degrees of resemblance, and expresses these in a systematic arrangement or *classification*,—designates them by appropriate appellations, and distinguishes them by clear and precise descriptions in scientific language; so that not only may the name and place in the system, the known properties, and the whole history of any given plant, be readily and surely obtained by the learner, but likewise an interesting view may be obtained of the general scheme or plan of the Creator in the Vegetable World.

684. Our present endeavor will be to explain the general principles of natural-history classification, and the foundation, or facts in nature, upon which it rests, and then cursorily to show how these are applied to the actual arrangement of the known species of plants.

CHAPTER I.

OF THE PRINCIPLES OF CLASSIFICATION.

685. PLANTS and animals—the members of the organic kingdoms of nature—exist as *individuals* (13), of definite kinds, each endowed with the characteristic power of producing like individuals and so of continuing the succession. The different sorts (1.) are reproduced true to their essential characteristics from generation to generation; and (2.) they exhibit unequal and very various degrees of resemblance or of dissimilarity among themselves. These simple propositions lie at the foundation of all classification and system in natural history. Upon the first rests the idea of *species*; upon the second that of *genera, orders*, and all groups higher than species.

686. *Individuals*. The idea of individuality is derived from man and ordinary animals, and thence naturally extended to vegetables. Individuals are beings, owing their existence and their characteristics to similar antecedent beings, and composed of parts which together constitute an independent whole, indivisible except by mutilation. Individuality is perfectly exemplified in all the higher and most of the lower animals, which multiply by sexual propagation only, and in which the offspring, or the *orun*, early separates from the parent; but it is incompletely realized in those animals of the lower grade which are propagated by buds or offshoots as well as by ova, and where the offspring may remain more or less intimately connected with the parent. Still more is this so in plants, which in every grade are or may be propagated by buds or offshoots; which in vegetation develop an indefinite number of similar parts; which produce branches like the parent plant, and capable either of continuing to grow in connection with it, or of becoming independent (232). The individual plant, therefore, is evidently not a simple and true individual in the proper sense of the word,—in the sense that an ordinary animal is. A kind of social or corporate individuality in the complex radiated animals often gives a certain limitation and shape to the congeries or *polypidom*, and in many of them even subordinates certain parts to the common whole, assigning to them special functions for the common weal: and this is universally and more strikingly the case with plants, except the very simplest.

So that for practical purposes, and in a loose, general sense, we take the whole plant as an individual, so long as it forms one connected mass, and no longer. But in a philosophical view we cannot well regard this congeries as the true vegetable individual.

687. Accordingly many botanists (of whom are Thouars at the beginning of the present century, and Braun* at the present day) regard as the true individual the shoot, or simple axis with its foliage, &c., whether this be the primary stem with its roots implanted in the soil, or a branch implanted on the stem. This view simplifies our conception of a vegetable, but is itself open to all the objections it raises against the individuality of the plant as a whole. For just as the herb, shrub, or tree is divisible into shoots or series of similar axes, so the shoot is divisible into similar component parts, or phytons (163), indefinitely repeated, and which may equally give rise to independent plants. Those philosophical naturalists, therefore, who find no stable ground in this position, are forced towards one of two opposite extremes. Some, justly viewing sexual reproduction as of the highest import, are led to regard the whole vegetative product of a seed as theoretically constituting one individual, whether the successive growths remain united, or whether they form a thousand or a million of vegetables, as may often happen. According to this view, all the Weeping-Willow trees of this country are parts of one individual; and most of our Potato plants must belong to one multitudinous individual, while others wholly similar, but freshly grown from seed, are each individuals of themselves; — a view which apparently amounts to an absurdity in terms and in fact. Others, following out the idea mentioned above, and laying the main stress upon simplicity and indivisibility, rather than upon tendency to separation, regard the phyton in ordinary plants, and the cell in those of lowest grade, as on the whole best answering, in the vegetable kingdom, to the simple individual in the animal. But this is merely a question of greater or less analogy. For the individual, in the proper sense of the term, is more or less confluent into a vegetative cycle in all plants, and in many of the lower animals, and attains full realization only in the higher grades of organized existence.

* See his elaborate treatise, *On the Vegetable Individual in its Relation to Species* (of which a translation from the German, by C. F. Stone, was published in the *American Journal of Science and the Arts*, vols. 19 and 20, 1855), for the completest development of this view, and for the history of the subject generally.

688. But, whatever it may be which we practically or philosophically regard as the vegetable individual, it is evident that plants as well as animals occur in a continued succession of organisms or beings which stand in the relation of parent and offspring. Each particular sort is a chain, of which the individuals are the links. To this chain, or (as expressed by Linnæus) this *perennial succession of individuals*, the natural-historian applies the name of

689. *Species* (14). Every one knows that the several sorts of plants and animals steadily reproduce themselves, or, in other words, keep up a succession of essentially similar individuals, and under favorable circumstances increase their numbers. Each particular kind of cultivated plant or domesticated animal is represented before our eyes in a mass of individuals, which we know from observation to a certain extent, and from necessary inference, have sprung from the same stock. And common observation has led people everywhere to expect that the different sorts will continue true to their kind, or at least to conclude that the different sorts of plants or of animals do not shade off one into another by insensible gradations, like the colors of the rainbow, as would have been the case if there were not distinct kinds at the beginning, and if their distinctions were not kept up, unmingled, and transmitted essentially unaltered, from generation to generation. So we naturally assume that the Creator established a definite, although a vast, number of types or sorts of plants and animals, and endowed them with the faculty of propagation each after its kind; and that these have so continued unchanged in all their essential characteristics. Out of these general observations and conceptions the idea of species must have originated; from them we deduce its scientific definition. Namely, that the species is, abstractly, the type or original of each sort of plant, or animal, thus represented in time by a perennial succession of like individuals, or, concretely, that it is the sum of such series or congeries of individuals; and that all the descendants of the same stock, and of no other, compose one species. And, conversely, as we can never trace back the genealogy far, we naturally infer community of origin from fraternal resemblance; that is, we refer to the same species those individuals which are as much alike as those are which we know to have sprung from the same stock.*

* We use the word *stock* advisedly, (and in one of its proper meanings, that of the original or originals of a lineage,) to avoid the assertion or denial of the

690. Specific identity is not of course inferred from every strongly marked resemblance; for the resemblance may be only that of genus, and individuals so related are inferred not to have had a common origin. Nor is it denied on account of every difference; for individuals of the same stock may differ considerably; in fact, no two plants are exactly alike, any more than two men are. Such differences when they become distinctly marked give rise to

691. *Varieties.* If two seeds from the same pod are sown in different soils, and submitted to different conditions as respects heat, light, and moisture, the plants that spring from them will show marks of this different treatment in their appearance. Such differences are continually arising in the natural course of things, and to produce and increase them artificially is one of the objects of cultivation. Such variations in nature are transient; the plant often outlasting the cause or outgrowing its influence, or else perishing from the continued and graver operation of the modifying influences. But in the more marked varieties which alone deserve the name, the cause of the deviation is occult and constitutional; the deviation occurs we know not why, and continues throughout the existence and growth of the herb, shrub, or tree, and consequently through all that proceeds from it by propagation from buds, as by offsets, layers, cuttings, grafts, &c. In this way choice varieties of Apples, Pears, Potatoes, and the like, are multiplied and perpetuated.

692. Since the progeny inherits or tends to inherit all the characters and properties of the parent, constitutional varieties must have a tendency to be reproduced by seed, — a tendency which might often prevail, within certain limits, over that general influence which would remand the variety to the normal state, were it not for the commingling which so commonly occurs in nature, through the casual fertilization of the ovules of one individual by the pollen of other individuals of the same species. By assiduously pursuing the oppo-

origin of each species from a single individual or a single pair, — a question which science does not furnish grounds for deciding. It is evidently more simple to assume the single origin, where there is no presumption to the contrary, as there may be in the case of trioscious or of organically associated plants or animals; but the contrary supposition does not affect our idea of species, if we suppose the originals to have been as much alike as individuals proceeding from the same parent are, and to have had a common birthplace. The investigation of the geographical distribution of plants more and more favors the idea of the dissemination of each species from a centre of its own.

site course in domesticated plants, that is, by constantly insuring the fertilization of the ovules of a marked variety by the pollen of the same, and by saving seed only from such of the resulting progeny as possess the desired peculiarity in the highest degree, and so on for several generations, it would appear that

693. *Races*, viz. varieties whose characteristics are transmissible by seed with considerable certainty, may generally be produced. Of this kind are the particular sorts of Indian Corn, Rye, Cabbage, Lettuce, Radishes, &c., and indeed of nearly all our varieties of cultivated annual and biennial esculent plants, as well as of several perennials, many of which have been fixed through centuries of domestication. What is now taking place with the Peach in this country may convince us that races may be developed in trees as well as in herbs, and in the same manner; and that the reason why most of our cultivated races are annuals or biennials is because these can be perpetuated in no other way, and because the desired result is obtainable in fewer years than in shrubs or trees. Although races hardly exist independently of man, he cannot be said to originate their peculiarities, nor is it known how they originate. The *sports*, as the gardener calls them, appear as it were accidentally in cultivated plants. The cultivator merely selects the most promising sorts for preservation, leaving the others to their fate. By particular care he develops the characteristic feature, and strengthens and fixes, in the manner already explained, the tendency to become hereditary, so securing the transmissibility of the variety as long as he takes sufficient care of it. If not duly cared for, they dwindle and lose their peculiarities, or else perish; if allowed to mix with normal forms, they revert to the common state of the species. Were cultivation to cease, all these valued products of man's care and skill would doubtless speedily disappear; the greater part, perhaps, would perish outright; the remainder would revert, in a few generations of spontaneous growth, to the character of the primitive stock.

694. Although man has no power to create the peculiarities of such varieties, he may manage so as not only largely to increase them, but also to combine the peculiarities of widely different varieties of a species, and thereby produce novel results. This is effected by *Cross-breeding*, i. e. by fertilizing the pistil of one variety with the pollen of another variety of the same species. In this way most esteemed new varieties of flowers and fruits are originated, which combine the separate excellences of both parents. The cultivator

often proceeds one step farther, in certain cases, and gives rise to a different kind of *cross-breeds*, viz.

695. *Hybrids*. These are cross-breeds from different but nearly related species. It is well known that, by proper precautions, the pistil of a flower of one species may often be fertilized by the pollen of another of a similar constitution, and that the plants raised from the seeds so produced combine the characters and properties of both parents. Some kinds, such as Azaleas and Pelargoniums, hybridize very readily; in others hybridism is effected with difficulty between nearly related species. The gardener produces hybrids among most of his favorite plants, and variously cross-breeds and mingles them, so as to confuse the limits of many cultivated species. But in nature hybrids rarely occur. Not more than fifty wild kinds are clearly known as of continued or frequent occurrence. Others may perhaps be originated from time to time; but their existence is transient. For hybrids are generally, if not always, sterile, and therefore incapable of perpetuation by seed. But their ovules may be fertilized by the pollen of either of their parents, when the progeny reverts to that species, probably retaining, however, some traces of the mixture, unless this should be obliterated by successive fertilizations from individuals of the same parent species. It is probable that cross-fertilization between different individuals of the same species is more common than is generally supposed, and that it is one of Nature's means for repressing variation. On the other hand, continued self-fertilization (or breeding in and in) is almost sure to perpetuate, as well as farther to develop, individual peculiarities, i. e. those of variety or race.

696. However plants may be modified by art and man's device, the systematic botanist proceeds upon the ground that the distinctions between species, whether small or great, are real, and in nature are permanent, — that variation, wide as it may be, is naturally restricted within certain limits. And this appears to be true. As distinctions subordinate to species are in nature both indefinite and transitory, these, however important to the cultivator, are of little account with the systematic botanist.

697. *Species* are the true subjects of classification. And the end and aim of systematic botany is to ascertain and to express their relationship to each other. The whole ground in nature for the classification of species is the obvious fact that species resemble or differ from each other unequally and in extremely various de-

gress. If this were not so, or if related species differed one from another by a constant quantity, so that, when arranged according to their resemblances, the first differed from the second about as much as the second from the third, and the third from the fourth, and so on throughout,—then, with all the diversity in the vegetable kingdom there actually is, there could be no natural foundation for their classification. The multitude of species would render it necessary to classify them, but the classification would be wholly artificial and arbitrary. The actual constitution of the vegetable kingdom, however, as appears from observation, is, that some species resemble each other very closely indeed, others differ as widely as possible, and between these the most numerous and the most various grades of resemblance or difference are presented, but always with a manifest tendency to compose groups or associations of resembling species,—groups the more numerous and apparently the less definite in proportion to the number and the nearness of the points of resemblance. These various associations the naturalist endeavors to express, as far as is necessary or practicable, by a series of generalizations,—of which the lower or particular are included in the higher,—based on the more striking, or what he deems the most important (i. e. the most definite or least exceptional) points of resemblance of several grades. Linnaeus and the naturalists of his day mainly recognized three grades of association, or groups superior to *species*, viz. the *genus*, the *order*, and the *class*; and these are still the principal members of classification. Of these

698. *Genera* (plural of *Genus*) are the more particular or special groups of related species. They are groups of species which are most alike in all or most respects,—which are constructed, so to say, upon the same particular model, with only circumstantial differences in the details. They are not necessarily nor generally the lowest definable groups of species, but are the *lowest most clearly definable* groups which the botanist recognizes and accounts worthy to bear the generic name; for the name of the genus with that of the species added to it is the scientific appellation of the plant or animal. Constituted as the vegetable and animal kingdoms are, the recognition of genera, or groups of kindred species, is as natural an operation of the mind as is the conception of species from the association of like individuals. This is because many genera are so strongly marked, or at least appear to be so, as far as ordinary observation extends. Every one knows the *Rose* genus, composed of

the various species of Roses and Sweetbriars; the Bramble genus, comprising Raspberries, &c., is popularly distinguished to a certain extent; the Oak genus is distinguished from the Chestnut and the Beech genus, &c.: each is a group of species whose mutual resemblance is greater than that of any one of them to any other plant. The number of species in such a group is immaterial, and in fact is very diverse. A genus may be represented by a single known species, when its peculiarities are equivalent in degree to those which characterize other genera,—a case which often occurs; although if this were generally so, genus and species would be equivalent terms. If only one species of Oak were known, the Oak genus would have been as explicitly discerned as it is now that the species amount to two hundred; it would have been equally distinguished by its acorn and cup from the Chestnut, Beech, Hazel, &c. Familiar illustrations of genera in the animal kingdom are furnished by the Cat kind, to which belong the domestic Cat, the Catamount, the Panther, the Lion, the Tiger, the Leopard, &c.; and by the Dog kind, which includes with the Dog the different species of Foxes and Wolves, the Jackal, &c. The languages of the most barbarous people show that they have recognized such groups. Naturalists merely give to them a greater degree of precision, and indicate what the points of agreement are.

699. If all such groups were as definite and as conspicuously marked out as those from which illustrations are generally taken, genera might be as natural as species. But unfortunately the purely popular genera are comparatively few, and although often correctly founded by the unscientific, yet they are as frequently wrongly limited, or based upon fanciful resemblances. Popular nomenclature, embodying the common ideas of people, merely shows that generic groups are recognizable in a considerable number of cases, but not that the whole vegetable or the whole animal kingdom is divisible into a definite number of such groups of equally or somewhat equally related species. Whether this proves to be so or not, and whether genera are actually limited groups throughout, this is not the place to consider. Suffice it to say, that there is a ground in nature for genera, and that the naturalist is obliged to treat them, for systematic purposes, as strictly definite groups of species. While genera represent the closer relationships of species,

700. *Orders or Families* (as they are interchangeably called in botany) express remoter relationships or more general resemblances.

They are groups of kindred genera, or rather *genera of a higher grade*. For example, Oaks, Chestnuts, Beeches, Hazels, and Hornbeams constitute so many genera, which, although quite distinct, have so strong a family likeness, and are so much alike in their general structure and properties, that they are associated into one order or family group (the Oak family); while the Birches and the Alders form another order not very different in character, and the Walnuts and Hickories another. So the Pines, Firs or Spruces, Larches, Cedars, &c., obviously related among themselves so much more than they are to any other genera, are members of the Pine family; the Raspberry, Blackberry, and Strawberry, with many others, are associated with the Rose in the Rose family; and so on.

701. Classes are to orders what these are to genera. They express more extensive, or the most extensive relations of species, each class embracing all those species which are framed upon the same general plan of structure, however differently that plan may be carried out in particulars. Thus all Exogenous or Dicotyledonous plants constitute one class, their stems, their embryo, their leaves, &c. being constructed upon the same general plan in all the species, while Endogenous or Moncotyledonous plants for the same reasons compose another class.

702. The sequence of groups, rising from particular to universal, is Species, Genus, Order, Class; or, in descending from the universal to the particular,

CLASS,
ORDER,
GENUS,
SPECIES.

703. These are the common framework of all methods of classification, both in the animal and the vegetable kingdoms. But these do not exhaust our powers of analysis, nor express all the gradations which we may observe in the relationship of species. They merely gather up what are deemed the most essential indications of relationship, and express them under three grades superior to species, which always carry with them distinctive names. But a more elaborate analysis is often requisite, on account of the large number of objects to be arranged, and the various degrees of relationship which may come into view. And these, when needful, are expressed in a series of intermediate groups or divisions, which may or may not require distinctive names. Names for them are, however, a

great convenience, especially for those which are most natural and definite. For some of these intermediate groups may be as distinctly marked as are those which we call genera or orders.

704. The great advantages and proper use of this intermediate grouping are, that it secures all the benefits of complete analysis without undue multiplication of genera and orders, and that, by extending the scale, more grades of relationship may be noted, and the whole expressed in our systems in truer perspective: Accordingly, when groups of species below what we take for genera are recognized, and found to be so well marked that by a little lowering of the scale they would be received as genera, they are denominated SUBGENERA. If less definite, we term them merely *Sections*. For example, *Pyrus*, the Pear genus, embraces Apples, Pears, Crab-apples and the like; and the Pear itself is the type or normal representative. From this the Apple and the several species of Crab-apple differ considerably, but not quite enough to warrant generic separation: they are therefore recognized as forming a subgenus, *Malus*, of the genus *Pyrus*. Again, the Bramble genus, *Rubus*, comprises both Raspberries and Blackberries, which, although distinguished by everybody, are not so much or so definitely different from each other as Apples and Crab-apples are from Pears; so they are ranked merely as sections of the Bramble genus. If we were to receive all such particular groups of species as genera, and give them substantive names, as many naturalists are doing, the nicer gradations of affinity would be disregarded, while genera would be reckoned by tens of thousands; at length half our species would become genera with substantive names, and the whole advantage of classification and nomenclature would be lost. The proper discrimination of genera is the real test of a naturalist.

705. When groups intermediate between genera and orders are admitted, they are generally denominated TRIBES, and their divisions, if any, SUBTRIBES. But the highest divisions of orders, when marked by characters of such importance that it might fairly be questioned whether they ought not to be received as independent orders, take the name of SUBORDERS. For example, the great Rose family, as we receive it, embraces three suborders; one of them represented by the Plum, Peach, Almond, &c.; a second, by the Pear, Quince, Hawthorn, and the like; and the third, by the Rose itself and its immediate relatives. Some botanists receive these three as so many orders: we regard them as suborders, be-

cause of the strong family likeness which pervades the whole, and of the transitions between them. In the larger of these suborders, or the proper Rose family, we recognize three tribes: one represented by the Rose genus itself; one by the Bramble genus, with the Strawberry, Cinquefoil, Avens, &c.; and the third by Spiræa and its pear relations. And, again, the second and larger of these embraces genera which are different enough to be ranked under several subtribes.

706. Upon the same principles, groups may be interposed between the orders and the classes, of which the highest kind will take the name of **SUBCLASSES**. And even above classes we have the most comprehensive division of all plants into a higher and a lower grade or **SERIES** (98); which brings us up to the vegetable **KINGDOM**, one of the three great departments of Nature.

707. To exhibit the whole sequence or stages of natural-history classification, so that the student may see the relative rank of groups, designated by the terms which have now been explained, they are here presented, arranged in a descending series, beginning with the primary division of natural objects into kingdoms, and indicating by small capitals those of fundamental importance and universal use in classification.

KINGDOMS,
 Series,
 CLASSES,
 Subclasses,
 ORDERS or FAMILIES,
 Suborders,
 Tribes,
 Subtribes,
 GENERA,
 Subgenera,
 SPECIES,
 Varieties,
 Individuals.

708. **Characters.** An enumeration of the distinguishing marks, or points of difference between one class or order, &c. and the others, is termed its *character*. Characters accordingly properly embrace only those points which are common to all plants of the group, but not to the other groups of the same rank. The characters of classes, &c. are restricted to those general peculiarities of structure upon which these great groups are established: the *ordinal character* recites the particulars in which the plants it comprises differ

from all others of the class ; the *generic character* enumerates those points which distinguish the plants of the genus in question from all others of the same order or suborder ; the *specific character* indicates the differences between species of the same genus ; — to which in botanical works more or less of general *description*, according to the plan and extent of the work, is generally added.

709. A complete system of Botany will therefore comprise a methodical distribution of plants according to their organization, with their characters arranged in proper subordination ; so that the investigation of any one particular species will bring to view, not only its name (which separately considered is of little importance), but also its plan of structure, both in general and in particular, its relationships, essential qualities, and whole natural history. The classification and the method of investigation in natural history constitute not only the most complete arrangement known for the collocation of a vast amount of facts, but also the best system of practical logic ; and the study exercises and sharpens at once both the powers of reasoning and of observation, more, probably, than any other pursuit. As a system for collocating facts for convenient reference, a great practical advantage of natural history is secured by its happily devised

710. *Binomial Nomenclature.* Since the time of Linnæus, who introduced the system, the scientific name of every plant is expressed by two words, viz. by the name of its species appended to that of its genus, each of a single word. That of the genus, i. e. the generic name, is a substantive ; that of the species, or the specific name, is an adjective adjunct. The same name is never employed for different genera ; the same specific name is not available for more than one species of the same genus, but may be used in any other genus. A few thousand names accordingly serve completely to designate something like 8,000 genera and nearly 100,000 species of plants, in a manner which obviates all confusion, and does not greatly burden the memory. The generic name of a plant answers to the surname of a person, as *Brown* or *Jones* ; the specific name answers to the baptismal name, as *John* or *James*. Thus, *Quercus alba* is the botanical appellation of the White Oak ; *Quercus* being the substantive name for the genus, and *alba* (white) the adjective name for this particular species ; while the Red Oak is named *Quercus rubra* ; the Scarlet Oak, *Quercus coccinea* ; the Live Oak, *Quercus virens* ; the Bur Oak, *Quercus macrocarpa* ; and so on.

The scientific names of plants are all Latin or Latinized ; and that of the species always follows that of the genus.

711. Generic names in botany are derived from various sources. Those of plants known to the ancients generally preserve their classical appellations ; as, for example, *Quercus*, *Fagus*, *Corylus*, *Prunus*, *Myrtus*, *Viola*, &c. For plants since made known, even their barbarous names are often adopted, when susceptible of a Latin termination, and not too uncouth ; for example, *Thæa* and *Coffæa*, for the Tea and Coffee plants, *Bambusa* for the Bamboo, *Yucca*, *Negundo*, &c. But more commonly, new generic names, when wanted, have been framed by botanists to express some botanical character, habit, or obvious peculiarity of the plants they designate ; such as *Arenaria*, for a plant which grows in sandy places ; *Dentaria*, for a plant with toothed roots ; *Lunaria*, for one with moon-like pods ; *Sanguinaria*, for the Bloodroot with its sanguine juice ; *Crassula*, for some plants with remarkably thick leaves. These are instances of Latin derivatives ; but recourse is more commonly had to the Greek language, in which compounds of two words are much more readily made, expressive of peculiarities ; such as *Menispermum*, or Moonseed ; *Lithospermum*, for a plant with stony seeds ; *Melanthium*, for a genus whose flowers turn black or dusky ; *Epidendrum*, for certain Orchideous plants which grow upon trees ; *Liriodendron*, for a tree which bears lily-shaped flowers, &c. Genera are also dedicated to distinguished persons ; a practice commenced by the ancients ; as *Pæonia*, which bears the name of Pæon, who is said to have employed the plant in medicine ; and *Euphorbia*, *Artemisia*, and *Asclepias* are also examples of the kind. Modern names of this kind are freely given in commemoration of botanists, or of persons who have contributed to the advancement of natural history. *Magnolia*, *Bignonia*, *Lobelia*, and *Lonicera*, dedicated to Magnol, Bignon, Lobel, and Lonicer, are early instances ; *Linnaea*, *Tournefortia*, *Jussiaea*, *Halleria*, and *Gronovia*, bear the names of the most celebrated botanists of the eighteenth century ; and at the present day almost every devotee of the science is thus commemorated.

712. Specific names are adjuncts, and mostly adjectives, adopted on similar principles. Most of them are expressive of some characteristic or obvious trait of the species ; as, *Magnolia grandiflora*, the Large-flowered Magnolia ; *M. macrophylla*, the Large-leaved Magnolia ; *M. glauca*, which has the foliage glaucous or whitened underneath ; or *Viola tricolor*, from the three-colored corolla of the

Pansy; *V. rostrata*, a remarkably long-spurred species; *V. rotundifolia*, with rounded leaves; *V. lanceolata*, with lanceolate leaves; *V. pedata*, with pedately parted leaves; *V. primulaefolia*, where the leaves are compared to those of the Primrose; and *V. pubescens*, with pubescent or hairy herbage. Sometimes the specific name refers to the country which the plant inhabits or was first found in, as *Viola Canadensis*, the Canadian Violet; or to the station where it naturally grows, as *V. palustris* (Marsh Violet). Sometimes it commemorates the discoverer or describer, when it rightly takes the genitive form, as *Viola Muhlenbergii*, *V. Nuttallii*, &c. When commemorative names are given merely in compliment to a botanist unconnected with the discovery or history of the plant, the adjective form is preferred; as, *Carex Torreyana*, *C. Hookeriana*, &c.: but this rule is not universally followed. Specific names are sometimes substantive; as, *Magnolia Umbrella*, *Ranunculus Flammula*, *Hypericum Sarothra*, *Linaria Cymbalaria*, &c. (most of these being old generic names used as specific); when they do not necessarily accord with the genus in gender. These, as well as all specific names taken from persons or countries, are to be written with a capital initial letter.

713. Varieties may be designated by names when they are remarkable enough to require it. The name of the variety, when used at all, follows that of the species, and is formed on the same plan. Subgenera need to be designated by names, which are substantive, and on the same principle as generic names. These are convenient to refer to, but are not a part of the proper name of a plant, which is that of the genus and species only.

714. The names of genera and species are the same in all botanical systems, and therefore are properly alluded to here. But those of orders, and all other groups higher than genera, vary in plan with the system adopted. Classifications are of two sorts, viz.

715. **Natural and Artificial Systems.** A natural system carries out in practice as perfectly as possible the principles sketched in this chapter, arranging all known species in groups of various grades in view of their whole plan of structure, so placing each genus, tribe, order, &c. next to those it most resembles in all respects. An artificial system arranges the genera by some one character, or set of characters, chosen for convenience, disregarding other considerations. It aims only to provide an easy mode of ascertaining the names of plants, and does not attempt to express their points of resemblance generally, but serves nearly the same purpose as a dictionary.

716. Artificial systems are no longer used in botany, except as keys or helps in referring plants to their proper groups in natural arrangements. But the celebrated Artificial System of Linnæus so long prevailed, and has exerted so great an influence over the progress of the science, that it is still desirable for the student to understand it. It will therefore be explained, after we have illustrated the principles of the Natural System of Botany.

CHAPTER II.

OF THE NATURAL SYSTEM OF BOTANY.

717. THE object proposed by the Natural System of Botany is to bring together into groups those plants which most nearly resemble each other, not in a single and perhaps relatively unimportant point (as in an artificial classification), but in all essential particulars; and to combine the subordinate groups into successively more comprehensive natural assemblages, so as to embrace the whole vegetable kingdom in a methodical arrangement. All the characters which plants present, that is, all their points of agreement or difference, are employed in the classification; those which are common to the greatest number of plants being used for the primary grand divisions; those less comprehensive, for subordinate groups, &c.; so that the *character*, or description of each group, when fully given, actually expresses the main particulars in which the plants it embraces agree among themselves, and differ from other groups of the same rank. This complete analysis being carried through the system, from the primary divisions down to the species, it is evident that the study of a single plant of each group will give a correct general idea of the structure, habits, and even the sensible properties, of the whole.

718. For it is evident that the relationships of plants are real; that there is not only a general plan of vegetation (with which the student has already become familiar), but also a plan in the relations which subsist between one plant and another; that the species sustain to each other the relation of parts to a whole, — so that this *whole*, or vegetable kingdom, is an organized *system*. And this *sys-*

far as comprehended, may be to a good degree expressed in our classification. This idea of plan and system in nature supposes a Planner, or a mind which has ordered things so, with intelligence and purpose; and it is this plan, or its evidences and results, which the naturalist is endeavoring to investigate. The botanist, accordingly, does not undertake to contrive a system, but he strives to express in a classification, as well as he can, the System of Nature, or, in other words, the *Plan of the Creator in the Vegetable Kingdom*.

719. "So there can be only one natural system of botany, if by the term we mean the plan according to which the vegetable creation was called into being, with all its grades and diversities among the species, as well of past as of the present time. But there may be many natural systems, if we mean the attempts of men to interpret and express the plan of the vegetable creation,—systems which will vary with our advancing knowledge, and with the judgment and skill of different botanists,—and which must all be very imperfect. They will all bear the impress of individual minds, and be shaped by the current philosophy of the age. But the endeavor always is to make the classification a reflection of Nature, as far as any system can be which has to express such a vast and ever increasing array of facts, and most various and intricate relations, in a series of definite propositions, and have its divisions and subdivisions following each other in some fixed order." Our so-called natural methods must always fail to give more than an imperfect and considerably distorted reflection, not merely of the plan of the vegetable kingdom, but even of our knowledge of it; and every form of it yet devised, or likely to be, is more or less artificial, in some of its parts or details. This is inevitable, because,—

720. (1st.) The relationships of any group cannot always be rightly estimated before all its members are known, and their whole structure understood; so that the views of botanists are liable to be modified with the discoveries of every year. The discovery of a single plant, or of a point of structure before misunderstood, has sometimes changed materially the position of a considerable group in the system, and minor alterations are continually made by our increasing knowledge. (2d.) The groups which we recognize, and distinguish as genera, tribes, orders, &c., are not always, and perhaps not generally, completely circumscribed in nature, as we are obliged to assume them to be in our classification. This might be expected from the nature of the case. For the naturalist's groups, of what-

ever grade, are not *realities*, but *ideas*; their consideration involves questions, not of *things*, between which absolute distinctions might be drawn, but of *degrees of resemblance*, which may be expected to present infinite gradations. (3d.) Although the grades of affinity among species are most various, if not wholly indefinite, the naturalist reduces them all to a few, and treats his genera, tribes, &c. as equal units, or as distinguished by characters of about equal value throughout, — which is far from being the case. (4th.) The naturalist in his works is obliged to arrange the groups he recognizes in a lineal series; but each genus, or order, &c. is very often about equally related to three or four others; so that only a part of the relationship of plants can practically be indicated in the published arrangement.

721. The natural system as sketched by Bernard and A. L. Jus-sieu, and improved by the labors of succeeding botanists, essentially consists of an arrangement of the known genera according to their affinities under two hundred or more natural orders, and of these under a few great types or classes. What is now most wanted to complete the system is a truly natural arrangement of the orders under the great classes, like that of the genera under their respective orders. Until this is done, the series in which the orders follow one another in botanical works must not be regarded as a part of the system of nature. Different authors adopt different modes of arranging them; and all of them that a learner could use are avowedly more or less artificial.

722. Omitting all historical details and statements of more or less conflicting views, we will briefly sketch the outlines of the principal divisions of the vegetable kingdom, according to the natural system as we now practically receive it. In explaining the principles of classification, we proceeded from the individual to the class. In examining the actual construction of the system of botany, it is simpler to regard the vegetable kingdom as a whole, and show how it is naturally divided and subdivided. This is the course a student must follow with an unknown plant before him, which he wishes to refer first to its class, then to its order, and finally to its genus and species.

723. The long and complex series, stretching from the highest organized vegetable down to the simplest and minutest of the Fungi and Algæ, is most naturally divided, as we have already seen, into two parts, forming a higher and a lower grade or series (98), viz.

Series I. PHENOGAMOUS (or *Phanerogamous*) or *FLOWERING PLANTS* (114, 117), which produce flowers and seeds, the latter containing a ready-formed embryo.

Series II. CRYPTOGAMOUS or *FLOWERLESS PLANTS* (113, 117, 651), whose organs of reproduction are not flowers, but some more or less analogous apparatus, and which are propagated by spores or specialized cells.

724. We have next to consider how these two series may be themselves divided, in view of the most general and important points of difference which the plants they comprise exhibit. Whenever *Phænogamous* plants rise to arborescent forms, a difference in port and aspect at once arrests attention; that which distinguishes our common trees and shrubs from Palms and the like (Fig. 184). On examination, this is found to accompany a well-marked important difference in the structure of the stem or wood, and in its mode of growth. The former present the *exogenous*, the latter the *endogenous* structure or growth (200–203, 207, &c.). This difference is equally discernible, if not so striking, in the annual or herbaceous stems of these two sorts of *Phænogamous* plants. A difference is also apparent in their foliage; the former generally have *reticulated*, or *netted-veined*, the latter *parallel-veined* leaves (276). The leaves of the former usually fall off by an articulation; those of the latter decay on the stem (309, 310). The *Phænogamous* series, therefore, divides into two great classes, namely, into *EXOGENOUS* and *ENDOGENOUS* plants, more briefly named *EXOGENS* and *ENDOGENS*. The difference between the two not only pervades their whole port and aspect, but is manifest from the earliest stage, in the plan of the embryo. The embryo of *Exogens*, as already shown, is provided with a pair of cotyledons (or sometimes with more than one pair); that of *Endogens*, with only one; whence the former are also termed *DICOTYLEDONOUS*, and the latter *MONOCOTYLEDONOUS* plants (128, 641–643): names introduced by Jussieu, the father of this branch of botany.* Taking these divisions for classes, we have

* There is, perhaps, no real and complete exception to the coincidence of an exogenous stem with a dicotyledonous (or polycotyledonous) embryo, and of an endogenous stem with a monocotyledonous embryo. *Nyctaginaceæ* plants and some others have a few vascular bundles scattered through their pith, but the rest of the wood is regularly exogenous. The stalk of *Podophyllum* imitates an *Endogen*, but the subterranean rootstock is truly exogenous, as it should

Class I. EXOGENOUS OR DICOTYLEDONOUS PLANTS; those with endogenous stems, netted-veined leaves, and dicotyledonous (or rarely polycotyledonous) embryo;

Class II. ENDOGENOUS OR MONOCOTYLEDONOUS PLANTS; those with endogenous stems, mostly parallel-veined leaves, and monocotyledonous embryo.

725. Without entering here into a particular explanation of the diversities of structure which Cryptogamous plants present, suffice it to say that they exhibit three grades of simplification as to their vegetation, which appear to correspond with three different modes of fertilization. Plants of the highest grades of the Cryptogamous series have wood and ducts in their composition (i. e. they are vascular plants, 111), and display the ordinary type of vegetation, viz. with an axis or stem, bearing distinct foliage. But this stem in structure is neither endogenous nor exogenous, and grows from the apex only, having no primary root; whence these vascular Flowerless plants have been called *ACROGENS*, or *ACROGENOUS* plants. Of this kind are Ferns, Lycopodiaceæ, Equisetaceæ or Horsetails, &c. These plants, it appears, produce their organs analogous to flowers, and have their fecundation effected, once for all, upon the infantile or germinating plantlet, and the result is the origination of a bud, which develops into the adult plant; and that bears the fruit, in the form of spore-cases and spores (663). Here then are the characters of

Class III. ACROGENOUS PLANTS; Cryptogamous plants, with a distinct axis and mostly with foliage, having wood and ducts in their composition: fertilization occurring upon a transient germinating plantlet, and giving rise to the adult plant.

726. The other Cryptogamous plants, being composed of parenchyma only, (or with slight exceptions,) are called Cellular plants (111). Among them the Mosses and Liverworts present for the most part the ordinary plan of vegetation; their organs analogous to flowers appear in the adult plant; and the fertilization of the pistillidium gives origin to a sporangium in which a multitude of spores, capable of germination, are developed. These compose

Class IV. ANOPHYTES: cellular Cryptogamous plants, with distinct stem and foliage, or sometimes these parts confluent into a

be. The trunks or rootstocks of Water-Lilies appear to be endogenous; but those who have investigated them minutely, declare that they are not really so.

frond, composed of parenchyma alone : fertilization giving rise to a sporangium filled with spores.

727. The remaining and lower grade consists of plants such as Lichens, Seaweeds or Algæ, and Fungi, which exhibit no clear distinction into stem, root, and leaves, but consist of single cells or rows of cells in their lowest grades, and in the higher, of masses of cells disposed in almost every shape, but tending mostly to flat strata or expansions ; hence the vegetation is termed a *thallus* (or bed), and this word gives a name to the class, viz.

Class V. THALLOPHYTES: cellular Cryptogamous plants with no distinction of axis and foliage ; their spores mostly directly fertilized (as explained in another place, 656 – 661).

728. These five classes are unequal in extent and diversity ; the Exogenous class containing much the largest number of orders ; the Endogens also comprising a considerable number ; the others comprise few orders or main types, but are most of them very rich in tribes, genera, and species.

729. Only the first or highest class presents such marked diversity of type among the plants it comprises as to call for the establishment of subclasses, that is, of groups of such importance as to raise the question whether they should not be regarded as classes. This question is raised by the peculiarities of Coniferæ (Pines, Cypressess, the Yew, &c.), and by the tropical order of Cycadaceæ ; in which, not only are the flowers reduced to the greatest simplicity, but the fertile ones consist of naked ovules merely, borne on the margins or surface of a sort of open leaf, or else of an ovule, without anything answering to a pistil at all. But as these plants are truly exogenous and dicotyledonous (or often polycotyledonous), the better opinion is that they should be ranked under the Exogenous or Dicotyledonous class, as a subclass. So that, while the main body of the first class consists of

Subclass I. ANGIOSPERMOUS EXOGENS: viz. those with proper pistils enclosing their ovules in an ovary, in the ordinary manner ; the pollen to fertilize the ovules received upon a stigma (420, 559, 574), — the others form the

Subclass II. GYMNOSPERMOUS EXOGENS: those with naked ovules and seeds (as the name denotes), which are fertilized by direct application of the pollen (560, 573, 625).

730. The general plan of the classes and subclasses may be presented in one view, as in the subjoined synopsis.

SYNOPTICAL VIEW OF THE CLASSES IN THE NATURAL SYSTEM.

SER. I. PHLENOGAMOUS PLANTS, with {	Exogenous growth and a dictyodermous embryo.	Class I. EXOGENA, or DICOTYLEDONEA.
	Exogenous growth and a monostelidomous embryo.	" II. ENIKUENNA, or MONOSTELIDOMINA, " III. ENIKUENNA, or MONOSTELIDOMINA, " IV. ANOPHYTES, " V. THALLOPHYTES.
SER. II. CRYPTOGRAMOUS PLANTS, with {	a distinct axis, or stem and foliage, containing { woody and vascular tissue	Class III. AUKUENNA.
	cellular tissue only.	" IV. ANOPHYTES.
	no distinction of stem and foliage, but all confounded in a thallus.	" V. THALLOPHYTES.

731. The arrangement and general character of the principal orders under each class form the subject of the ensuing chapter. Before entering upon it, the

732. Nomenclature of Orders, Tribes, &c. requires some explanation. The names of such groups are in the plural number. As a general rule, the name of an order is that of some leading or well-known genus in it, prolonged into the adjective termination *aceæ*. Thus, the plants of the order which comprises the Mallow (*Malva*) are called *Malvaceæ*; that is, *Plantæ Malvaceæ*, or, in English, Malvaceous plants: those of which the Rose (*Rosa*) is the well-known representative are *Rosaceæ*, or Rosaceous plants, &c. Some few ordinal names, however, are differently formed, and directly indicate a characteristic feature of the group; as, for instance, *Leguminosæ*, or the Leguminous plants, such as the Pea, Bean, &c., whose fruit is a legume (610); *Umbelliferaæ*, or Umbelliferous plants, so named from having the flowers in umbels; *Compositæ*, an order having what were termed compound flowers by the earlier botanists (394); *Labiataæ*, so called from the labiate or two-lipped corolla which nearly all the species exhibit; *Cruciferaæ*, which have their four petals disposed somewhat in the form of a cross (Fig. 405).

733. Suborders, tribes, and all other groups between orders and genera, bear names framed upon the same principles, that is, they are plural, substantively-taken adjectives, derived from the name of some characteristic genus of the group. Thus the genus *Rosa* gives name to a particular tribe, *Rosææ*, of the order *Rosaceæ*; the genus *Malva* to the tribe *Malvææ*, of the order *Malvaceæ*, &c.,—the termination in *aceæ* being avoided, because reserved for ordinal names.

CHAPTER III.

ILLUSTRATIONS OF THE NATURAL ORDERS OR FAMILIES.

734. SOME authors (such as Jussieu and Endlicher) commence with the lower extremity of the series, and end with the higher; while others (as De Candolle) pursue the opposite course, beginning with the more perfect Flowering plants, and concluding with the

lowest grade of Flowerless plants. The first mode possesses the theoretical advantage of ascending by successive steps from the simplest to the most complex structure; the second, the great practical advantage of beginning with the most complete and best understood, and proceeding gradually to the most reduced and least known forms, or, in other words, from the easiest to the most difficult; and is therefore the best plan for the student.

735. Until the orders shall have been successfully associated into *natural alliances* or superior groups, (of whatever name,) it is most convenient to follow De Candolle's arrangement of them, in a general way, with such minor alterations as may be called for. The principal Floras now in use are arranged upon this general method. It commences with the Exogenous class, with those orders of it which are generally provided with complete flowers, and which exhibit the floral organs in the most normal condition, according to our theory of the blossom (Chap. IX., Sect. I - III.), that is, which have most of the several parts free and separate. It proceeds to those which are characterized by the union or consolidation of their floral organs, and then to those which are reduced or simplified by the suppression or obliteration of parts, ending with the Gymnospermous subclass, the flowers of which are extremely simplified. The Endogenous class succeeds, with a somewhat analogous arrangement, ending with Grasses; and the classes of the Cryptogamous series follow in the order of their rank.

736. The following cursory sketch takes in the principal orders, freely omitting, however, small and obscure ones, as well as certain well-characterized groups which have no interest to the ordinary student, and no indigenous, naturalized, or commonly cultivated representatives in the United States. Certain exotic orders are also omitted from the synopsis of the classes or large divisions, for greater simplicity, but are briefly mentioned in their proper place. Fuller accounts of the natural orders, and of their systematic arrangement, structure, properties, &c., must be sought in more extensive works, such as Lindley's *Vegetable Kingdom*, De Candolle's *Prodromus*, &c. As applied to the botany of this country, what is essential is comprised in the *Manual of the Botany of the Northern United States*, by the present writer, and in similar Floras. The characters of the orders, &c. are drawn up in ordinary botanical language. For explanation of the technical terms used, the reader may consult the Glossary at the end of the volume.

Series I. FLOWERING OR PHÆNOGAMOUS PLANTS.

Plants furnished with flowers (essentially consisting of stamens and pistils), and producing proper seeds.

Class I. EXOGENOUS OR DICOTYLEDONOUS PLANTS.

Stem consisting of a distinct bark and pith, which are separated by an interposed layer of woody fibre and vessels, forming *wood* in all perennial stems: increase in diameter effected by the annual deposition of new layers between the old wood and the bark, which are arranged in concentric zones and traversed by medullary rays. Leaves commonly articulated with the stems, their veins branching and reticulated. Sepals and petals, when present, more commonly in fives or fours, and very rarely in threes. Embryo with two (or rarely more) cotyledons.

Subclass 1. ANGIOSPERMOUS EXOGENOUS PLANTS.

Ovules produced in a closed ovary, and fertilized by the action of pollen through the medium of a stigma. Embryo with a pair of opposite cotyledons. (For convenience, the very numerous orders of this subclass are divided into those with polypetalous, monopetalous, and apetalous flowers. This holds in a general way; but a good many genera and species of mainly polypetalous, and some of monopetalous orders, are apetalous. The character of the following division must therefore be regarded as liable to exception in this respect. For example, many of the genera of the first order have apetalous flowers. — The earlier groups of this division are mostly hypogynous; those that succeed, perigynous; the last are epigynous.)

Division I. POLYPETALOUS EXOGENOUS PLANTS.

Calyx and corolla both present; and the petals distinct.

CONSPECTUS OF THE ORDERS.

Group 1. Ovaries several or numerous (in a few cases solitary), distinct, when in several rows sometimes cohering in a mass, but not united into a compound pistil. Petals and stamens hypogynous. Seeds albuminous.

* Stamens or pistils (one or both) numerous or indefinite.

Herbs without stipules.

RANUNCULACEÆ.

Shrubs or trees. Corolla imbricated in the bud.

MAGNOLIACEÆ.

Shrubs or trees. Corolla valvate in the bud.

ANONACEÆ.

- * * Stamens few or definite, mostly before the petals. Pistils one or few.
 Climbing plants. Dioecious or monœcious. MENISPERMACEÆ.
 Not climbing. Flowers perfect. Anthers opening by valves. BERBERIDACEÆ.
- Group 2.* Ovaries several and distinct, or perfectly united into a compound pistil of several cells. Embryo enclosed in a sac at the end of the albumen, or, in Nelumbium, without albumen. Aquatic herbs.
 Carpels distinct, immersed in a dilated top-shaped torus. NELUMBIACEÆ.
 Carpels united into a several-celled and many-ovuled ovary. NYMPHEACEÆ.
 Carpels distinct and free. Stamens 6-18. CAROMBACEÆ.
- Group 3.* Ovary compound, 5-celled, with the placenta in the axis. Stamens hypogynous, indefinite. Seeds numerous, anatropous, albuminous, with a small embryo. Marsh herbs, with singular pitcher-shaped or tubular leaves. SARRACENIACEÆ.
- Group 4.* Ovary compound, with parietal placenta. Petals and sepals 2 or 4, deciduous. Stamens hypogynous. Flower unsymmetrical. Embryo small, in copious albumen, or coiled when there is no albumen.
 Seeds albuminous : embryo small or minute.
 Polyandrous : flower regular. Juice milky or colored. PAPAVERACEÆ.
 Diadelphous or hexandrous : flower irregular. FUMARIACEÆ.
 Seeds without albumen : styles and stigmas united into one.
 Pod two-celled. Radicle folded on the cotyledons. CRUCIFERÆ.
 Pod one-celled. Embryo rolled up. CAPPARIDACEÆ.
 Seeds without albumen : styles or stigmas several. RESEDACEÆ.
- Group 5.* Ovary compound, with parietal placenta. Floral envelopes mostly 5-merous ; calyx persistent. Stamens hypogynous. Seeds albuminous.
 Anthers (5) adnate, introrse, connate. Corolla irregular. VIOLACEÆ.
 Anthers extrorse, or innate, distinct. Corolla regular.
 Vernation circinate. Petals marcescent. DROSERACEÆ.
 Vernation straight. Petals usually caducous. CISTACEÆ.
- Group 6.* Ovary compound, with the placenta parietal, or 2-5-celled from their meeting in the axis. Stamens hypogynous. Seeds with a straight embryo and little or no albumen.
 Sterile filaments or a lobed appendage before each petal. PARNASSIACEÆ.
 Sterile filaments none : leaves opposite.
 Stipules none : leaves dotted. Stamens unsymmetrical. HYPERICACEÆ.
 Stipules present : leaves dotless. Stamens symmetrical. ELATINACEÆ.
- Group 7.* Ovary compound, one-celled with a free central placenta, or 2-several-celled with the placenta in the axis. Calyx free or nearly so. Stamens hypogynous or perigynous. Embryo peripheric, coiled more or less around the outside of mealy albumen.
 Petals and stamens numerous. Ovary many-celled. MESEMBRYANTHEMACEÆ.
 Petals 3-5 or 6, sometimes wanting.
 Floral envelopes symmetrical. Stamens 10 or fewer. CARTOPHYLLACEÆ.
 Floral envelopes unsymmetrical, or stamens many. PORTULACACEÆ.

Group 8. Ovary compound and several-celled, with the placentæ in the axis; or the numerous carpels more or less coherent with each other or with a central axis. Calyx free from the ovary, with a valvate æstivation. Stamens mostly indefinite, monadelphous, or polyadelphous, inserted with the petals into the receptacle or base of the petals.

Anthers 1-celled, reniform. Stamens monadelphous. MALVACEÆ.

Anthers 2-celled. Fertile stamens few, monadelphous. BYTTNERIACEÆ.

Anthers 2-celled. Stamens polyandrous or polyadelphous. TILIACEÆ. *

Group 9. Ovary compound, with two or more cells, and the placentæ in the axis, free from the calyx, which is imbricated in æstivation. Stamens indefinite, or twice as many as the petals, usually monadelphous, hypogynous. — Trees or shrubs.

Leaves simple, not dotted. Stamens indefinite. CAMELLIACEÆ.

Leaves pellucid-punctate, mostly compound. AURANTIACEÆ.

Leaves compound, dotless. Stamens 10 or less, monadelphous.

Seeds single in each cell, wingless. MELIACEÆ.

Seeds several in each cell, winged. CEDRELACEÆ.

Group 10. Ovary compound, or of several carpels adhering to a central axis, (or rarely distinct in the last two), free from the calyx, which is mostly imbricated in æstivation. Stamens as many or twice as many as the petals, inserted on the receptacle, often monadelphous at the base. Embryo large. Albumen little or none. Flowers perfect, except in some Rutaceæ.

* Flower irregular and unsymmetrical. Albumen none.

Stamens united over the pistil. Ovules several in each cell. BALSAMINACEÆ.

Stamens distinct. Ovules single in each cell. TROPEOLACEÆ.

* * Flower regular and mostly symmetrical.

Leaves not punctate with transparent dots.

Calyx valvate. Albumen none: cotyledons very thick. LIMNANTHACEÆ.

Calyx imbricated in æstivation.

Embryo conduplicate: the radicle bent down on the convolute cotyledons.

GERANIACEÆ.

Embryo straight or nearly so.

Stamens (fertile) 5. Leaves simple, entire.

LINACEÆ.

Stamens 10. Leaves opposite, compound.

ZYGOPHYLLACEÆ.

Stamens 10. Leaves alternate, mostly compound.

Ovules more than one in each cell.

OXALIDACEÆ.

Ovules only one in each cell.

SIMARUBACEÆ.

Leaves punctate with transparent dots.

RUTACEÆ.

Group 11. Ovary one, or several and distinct or combined into one, with one or rarely two ovules in each cell. Calyx free; stamens more or less perigynous, as many or twice as many as the petals. Embryo large: albumen none. Shrubs or trees with a resinous or viscid-milky juice, and mostly polygamous or diœcious flowers. — In temperate climates represented only by

ANACARDIACEÆ.

Group 12. Ovary compound, 1-5-celled, with one or two ovules erect from the base of the cells. Calyx free or partly adherent. Stamens as many as the petals or sepals and opposite the former. Seeds anatropous, albuminous. Woody plants, with a colorless juice. Flowers regular. Leaves alternate.

Calyx obscure. Petals valvate, caducous. Embryo minute.

VITACEÆ.

Calyx more conspicuous than the petals, valvate.

RHAMNACEÆ.

Group 13. Ovary compound, 2-5-celled, with only one or two ovules in each cell. Stamens as many as the petals and alternate with them, perigynous. Seeds furnished with an arillus, albuminous, with a large straight embryo. Woody plants, with regular flowers and simple leaves.—Represented mainly by

CELASTRACEÆ.

Group 14. Ovary compound and 2-3-celled, with one or two (rarely 3 or 4) ovules in each cell, free from the calyx, which is imbricated in aestivation. Flowers often irregular, and sometimes unsymmetrical. Stamens definite, hypogynous or perigynous. Shrubs, trees, or herbs. Leaves opposite or alternate, not punctate.

Stamens distinct, inserted on a hypogynous or perigynous disk.

Embryo (except in *Staphylea*) variously curved or coiled, and destitute of albumen.

SAPINDACEÆ.

Stamens hypogynous, without a disk.

Stamens mostly monadelphous, 10.

Flowers regular. Embryo curved; albumen none.

MALPIGHIACEÆ.

Stamens monadelphous or diadelphous, 6 or 8. Flower irregular and unsymmetrical. Embryo straight in albumen.

POLYGALACEÆ.

Group 15. Ovary simple and solitary, free from the calyx; the fruit a pod. Flower 5-merous, the odd sepal anterior. Corolla papilionaceous, irregular, or sometimes regular. Stamens monadelphous, diadelphous, or distinct, mostly perigynous. Seeds destitute of albumen

Stamens hypogynous, the anterior wanting. Stipules none.

KRAMERIACEÆ.

Stamens mostly perigynous. Fruit a legume.

LEGUMINOSÆ.

Group 16. Ovaries one or several, either simple and distinct, or combined into a compound ovary with two or more cells and the placenta in the axis. Petals and the distinct stamens perigynous. Seeds destitute of albumen.

* Calyx free, although often enclosing the ovaries in its tube, except when the latter are united, when it is adnate to the compound ovary, and the stamens are indefinite.

Leaves alternate, stipulate. Cotyledons plane.

ROSACEÆ.

Leaves opposite, not stipulate, nor pellucid-punctate.

CALYCANTHACEÆ.

Leaves opposite, not stipulate, pellucid-punctate.

MYRTACEÆ.

** Calyx free from the compound ovary. Stamens definite.

LYTHRACEÆ.

- *** Calyx-tube adnate to the compound ovary. Stamens definite.
 Anthers opening by a pore at the apex. MELASTOMACEÆ.
 Anthers opening longitudinally.
 Stipules between the petioles. Leaves opposite. RHIZOPHORACEÆ.
 Stipules none. Calyx valvate.
 Cotyledons convolute. Fruit indehiscent, 1-celled. COMBRETACEÆ.
 Cotyledons plane. Fruit mostly 2-4-celled. ONAGRACEÆ.
- Group 17. Ovary compound, one-celled, with parietal placentæ. Petals and (with one exception) stamens inserted on the throat of the calyx. Flowers perfect, except in Papayaceæ.
- * Calyx adherent to the ovary.
 Albumen none or very little. Petals and stamens indefinite. CACTACEÆ.
 Albumen very copious. Embryo minute. Stamens 5. GROSSULACEÆ.
 Albumen present. Embryo rather large. Stamens indefinite. LOASACEÆ.
- ** Calyx free from the ovary.
 Flowers perfect. Stamens 5.
 Stamens distinct and perigynous. TURNERACEÆ.
 Stamens monadelphous, adnate to the gynophore. PASSIFLORACEÆ.
 Flowers dioecious. Stamens 10, on the corolla. PAPAYACEÆ.
- Group 18. Ovary compound, one-several-celled, the placentæ parietal (either truly or falsely so). Calyx adnate. Corolla frequently monopetalous. Stamens mostly united either by their filaments or anthers. Flowers dioecious or monœcious. Albumen none. Succulent or tender vines with tendrils. CUCURBITACEÆ.
- Group 19. Ovaries two or more, many-ovuled, distinct, or partly, sometimes completely, united, when the compound ovary is one-celled with parietal placentæ, or 2-many-celled with the placentæ in the axis. Calyx either free from the ovary or more or less adherent to it. Petals and stamens inserted on the calyx; the latter mostly definite. Seeds albuminous, numerous.
- Pistils of the same number as the sepals. CRASSULACEÆ.
 Pistils fewer than the sepals, more or less united. SAXIFRAGACEÆ.
- Group 20. Ovary compound, 2- (rarely 3-5-) celled, with a single ovule suspended from the apex of each cell. Stamens usually as many as the petals or the lobes of the adherent calyx. Embryo small, in hard albumen.
- * Summit of the (often 2-lobed) ovary free from the calyx; the petals and stamens inserted on the throat of the calyx. HAMAMELACEÆ.
- ** Calyx-tube entirely adherent to the ovary. Stamens and petals epigynous.
 Fruit separable into two dry carpels. Flowers umbellate. UMBELLIFERÆ.
 Fruit drupaceous, usually of more than two carpels. ARALIACEÆ.
 Fruit a 1-2-celled drupe. Flowers cymose or capitate. CORNACEÆ.

737. *Ord. Ranunculaceæ* (*Crowfoot Family*). Herbaceous, occasionally climbing plants, with an acrid watery juice, and usually palmately or ternately lobed or divided leaves, without stipules. Calyx of three to six, usually five, distinct sepals, deciduous, except in *Pæonia* and *Helleborus*. Petals five to fifteen, or often none. Stamens indefinite, distinct. Ovaries numerous, rarely few or solitary, distinct, in fruit becoming achenia (Fig. 566, 567) or follicles (Fig. 579, 648, 649), or in *Actæa* a berry. Embryo minute, at the base of firm albumen (Fig. 650, 610). — *Ex.* *Ranunculus*, the But-



tercup (Fig. 645), which has regular flowers with petals. *Clematis* (*Virgin's Bower*, which is the type of a tribe), *Anemone* (Fig. 411), *Hepatica* (*Liver-leaf*), &c. have no petals, but the calyx is petaloid. In these the flowers are regular. The *Larkspur* (Fig. 398) and *Monkshood* (Fig. 401) have the flowers irregular, and the *Columbine* (Fig. 646) has petals in the form of spurs. *Actæa* (*Baneberry*) and one *Larkspur* have a solitary ovary: in the latter the petals are consolidated. *Zanthorhiza* (*Yellow-root*) has only five or ten stamens. — The juice

of all *Ranunculaceæ* plants is acrid, or even caustic: some, as the *Aconite*, are virulent narcotico-acrid poisons.

738. *Ord. Dilleniaceæ*, consisting chiefly of tropical and Australian shrubs and trees, probably includes *Crossosoma* of Nuttall, a singular Californian genus. The order ranks between the preceding and succeeding, but is nearer the former, from which it is known by its arillate seeds.

FIG. 645. Vertical section of the flower of a Buttercup.

FIG. 646. Flower and part of a leaf of *Aquilegia Canadensis* (Wild Columbine). 647. A detached petal. 648. The five carpels of the fruit. 649. A separate follicle. 650. Vertical section of the seed, showing the minute embryo.

739. Ord. *Magnoliaceæ* (*Magnolia Family*). Trees or shrubs; with ample and coriaceous, alternate, entire or lobed leaves, usually punctate with minute transparent dots: stipules membranaceous, enveloping the bud, falling off when the leaves expand. Flowers solitary, large and showy. Calyx of three deciduous sepals, colored like the petals; the latter in two or more series of three. Stamens numerous, with adnate anthers. Carpels either several in a single row, or numerous and spicate on the prolonged receptacle; in the latter case usually more or less cohering with each other, and forming a fruit like a cone or strobile. Seeds mostly one or two in each carpel, sometimes drupaceous and suspended, when the carpels open, by an extensile thread, composed of unrolled spiral vessels. Embryo minute, at the base of homogeneous fleshy albumen. There are three well-marked suborders, by many ranked as orders, viz.:—



740. Subord. *Magnoliæ* (*Magnolia Family proper*), characterized principally as above, especially by the stipules and the imbricated spiked carpels:—represented by *Magnolia* and *Liriodendron*. The bark, &c. is bitter and aromatic, with some acidity.

741. Subord. *Winteræ* (*Winter's-Bark Family*) has no stipules, and the carpels occupy only a single verticil. These have more

FIG. 651. *Magnolia glauca*. 652. A stamen, seen from the inside, showing the two lobes of the adnate anther. 653. The carpels in fruit, persistent on the receptacle, and opening by the dorsal suture; the seeds suspended by their extensile cord of spiral vessels.

pungent and purer aromatic properties; as in *Illicium*, the Star-Anise, the seeds and pods of which furnish the aromatic oil of this name.

742. *Subord. Schizandraceæ* is monœcious or diœcious, with the pistils spicate or capitate on a prolonged receptacle; the stamens often monadelphous. Leaves sometimes toothed, destitute of stipules.—*Ex. Schizandra*. These are mucilaginous, with little aroma.

743. *Ord. Monimiaceæ* is a small group, found in the southern hemisphere, with pungent aromatic properties, most allied to the last order according to Dr. Hooker (or to *Calycanthaceæ*, according to Tulasne), but chiefly apetalous, and with opposite leaves.

744. *Ord. Anonaceæ* (*Custard-Apple Family*). Trees or shrubs, with alternate entire leaves, destitute of stipules. Flowers large, but dull-colored. Sepals 3. Petals 6, in two rows, valvate in aesti-



vation. Stamens numerous, in many rows, with extrorse anthers. Carpels few, or mostly numerous and closely packed together, sometimes cohering and forming a fleshy or pulpy mass in the mature

FIG. 664. Flowering branch of the Papaw (*Asimina triloba*) of the natural size. 665. The receptacle, with all but the pistils removed. 666. A stamen, magnified. 667. View of three baccate pods from the same receptacle (much reduced in size); one cut across, showing lengthwise, to show the large bony seeds. 668. Section of the seed, to show the ruminated albumen.

fruit. Seeds one or more in each carpel, with a hard and brittle testa: embryo minute, at the base of hard, ruminated albumen. The four species of our so-called Papaw (*Asimina*) are our only representatives of this chiefly tropical order, which furnishes the luscious custard-apples of the East and West Indies, &c. Aromatic properties, with some acidity in the bark, &c., prevail in the order. *Monodora* yields the calabash-nutmeg.

745. Ord. *Myristicaceæ* (*Nutmeg Family*), consisting of a few tropical trees (which bear nutmegs), differs from *Anonaceæ* in having monœcious or diœcious and apetalous flowers, &c. The aril and the albumen of the seeds are fine aromatics. The common *nutmeg* is the seed of *Myristica moschata* (a native of the Moluccas) deprived of the testa: *mace* is the aril of the same species. The *ruminated* albumen is nearly peculiar to this family and the *Anonaceæ*.

746. Ord. *Menispermaceæ* (*Moonseed Family*). Climbing or twining shrubby plants, with alternate and simple palmately-veined leaves, destitute of stipules; and small flowers in racemes or panicles, mostly diœcious, the parts commonly in two or more rows of three or four each. Calyx of three to twelve sepals, in one to three rows, deciduous. Petals as many as the sepals or fewer, small, or sometimes wanting in the pistillate flowers. Stamens as many as the petals, and opposite them, or two to four times as many: anthers

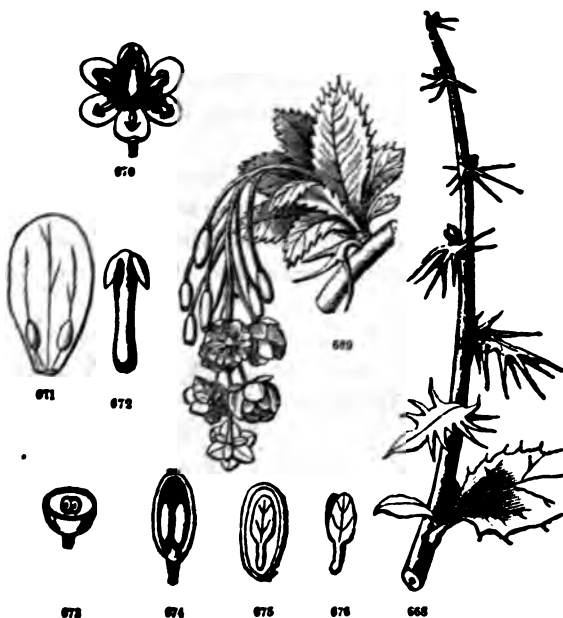


often four-celled. Carpels usually several, but only one or two of them commonly fructify, at first straight, but during their growth

FIG. 650. Staminate flower of *Menispermum Canadense*. 650. A stamen, with its four-lobed anther. 651. A pistillate flower of the same. 652. A solitary fruit. 653. Two drupes on the same receptacle, cut across; one through the pulpy exocarp only, the other through the bony endocarp and seed. 654. A drupe divided vertically (the embryo here is turned the wrong way). 655. The seed, and, 656, the coiled embryo detached.

often curved into a ring; in fruit becoming berries or drupes. Seeds solitary, filling the cavity of the bony endocarp: embryo large, curved or coiled in the thin fleshy albumen. — *Menispermum*, or *Moonseed* (Fig. 413, 414, 659–666), *Cocculus*. The roots are bitter and tonic (e. g. *Colombo Root* of the materia medica); but the fruit is often narcotic and acrid; as, for instance, the very poisonous *Cocculus Indicus* of the shops, once used for rendering malt liquors more intoxicating, and for stupefying fishes.

747. *Ord. Berberidaceæ (Barberry Family)*. Herbs or shrubs, with a watery juice; the leaves alternate, compound or divided, usually without stipules. Flowers perfect. Calyx of three to nine sepals, imbricated in one to several rows, often colored. Petals as



many as the sepals and in two sets, or twice as many, often with a pore, spur, or glandular appendage at the base. Stamens equal in

FIG 668. A shoot of *Berberis vulgaris*, the common Barberry. 669. A flowering branch from the axil of one of its leaves or spines, the following year. 670. An expanded flower. 671. A petal, nectariferous near the base. 672. A stamen; the anther opening by two valves. 673. Cross-section of a young fruit. 674. Vertical section; the seeds attached to the base. 675. Vertical section of a seed enlarged, showing the large embryo with two cotyledons and a taper radicle, surrounded by albumen. 676. The embryo naked.

number to the petals and opposite them, or rarely more numerous; anthers extrorse, the cells commonly opening by an uplifted valve (Fig. 475, 672). Carpel solitary, often gibbous or oblique, forming a one-celled pod or berry in fruit. Seeds sometimes with an aril: embryo (often minute) surrounded with a fleshy or horny albumen. — *Ex.* The Barberry, the sharp spines of which are transformed leaves; the Mahonias are Barberries with pinnated leaves. Caulophyllum thalictroides, the Blue Cohosh, is remarkable for its evanescent pericarp (559), and the consequent naked seeds, which resemble drupes. Podophyllum peltatum (the Mandrake) presents an exception to the ordinal character, having somewhat numerous stamens, with anthers which do not open by valves; but the latter anomaly is also found in Nandina. The order is remarkable for this valvular dehiscence of the anthers, and for the situation of both the stamens and petals opposite the sepals. But this latter peculiarity is easily explained away (461). The fruit is innocent or eatable; the roots, and also the herbage, sometimes drastic or poisonous, as in Podophyllum.

748. Ord. *Nelumbiaceæ* (*Nelumbo Family*). Aquatic herbs, with large leaves and flowers, on long stalks arising from a prostrate trunk or rhizoma, which has a somewhat milky juice: the leaves orbicular and centrally peltate. Calyx of four or five sepals, deciduous. Petals numerous, inserted in several rows into the base of a large and fleshy obconical torus, deciduous. Stamens inserted into the torus in several rows: the filaments petaloid; the anthers adnate and introrse. Carpels several, separately immersed in hollows of the enlarged flat-topped torus or receptacle (Fig. 427), each containing a single anatropous ovule; in fruit forming hard, round nuts. Seed without albumen: embryo very large, with two fleshy cotyledons, and a highly developed plumule. — *Ex.* The order consists of the single genus *Nelumbium*, embracing two species; one a native of Asia, the other of North America. They are chiefly remarkable for their large and showy leaves and flowers. The nuts are eatable. It should be regarded rather as a suborder of the next.

749. Ord. *Nymphæacæ* (*Water-Lily Family*). Aquatic herbs, with showy flowers and cordate or peltate leaves, arising from a prostrate trunk or rhizoma, and raised on long stalks above the water, or surface. Calyx and corolla of several or numerous petals, which gradually pass into each other; inserted on the fleshy torus which surrounds

or partly encloses and adheres to the pistil; the inner series gradually changing into stamens. Stamens numerous, in several rows, inserted into the torus with or above the petals; many of the outer filaments petaloid (Fig. 344), the adnate anthers introrse. Fruit indehiscent, pulpy when ripe, many-celled, crowned with the radiate stigmas; the anatropous seeds covering the spongy dissepiments. Embryo small, enclosed in a membranous bag, which is next the hilum, and half immersed in the mealy albumen. Structure of the trunk appearing rather endogenous than exogenous. — *Ex.* Nymphaea, the White Water-Lily; Nuphar, the Yellow Pond-Lily; and



the magnificent *Victoria* of tropical South America, the most gigantic and showy of aquatics, both as to its flowers and its leaves. Mucilaginous plants, with slight astringency; no important properties.

750. Ord. Cabombaceæ (*Water-shield Family*) is really merely a simplified state of the last, with only one series of sepals and petals,

FIG. 677. Open flower, with a flower-bud and leaf of the White Water-Lily (*Nymphaea odorata*); the inner petals passing into stamens. 678. A flower with all the parts around the pistil cut away except one of the petaloid stamens, one intermediate, and one proper stamen. 679. An inner petal, with the imperfect rudiments of an anther at the tip. 680. Transverse section of an ovary.

definite stamens, or nearly so, with innate anthers, and the gynæcium of few apocarpous, free, and few-ovuled pistils; the ovules chiefly on the dorsal suture. *Brasenia* and *Cabomba* are all the genera.



751. Ord. Sarraceniacæ (*Water-Pitcher Family*). Perennial herbs, growing in bogs; the (purplish or yellowish-green) leaves all radical and hollow, pitcher-shaped (Fig. 299, 300), or trumpet-shaped. Calyx of five persistent sepals, with three small bracts at its base. Corolla of five petals. Stamens numerous. Summit of the combined styles very large and petaloid, five-angled, covering the five-celled ovary, persistent. Fruit five-celled, five-valved, with a large placenta projecting from the axis into the cells. Seeds numerous, albuminous, with a small embryo.—*Sarracenia*, from which the above character is taken, was the only known genus of the order, until the recent discovery of *Heliophora* in Guiana, which is apetalous, its scape bearing several flowers; as does that of a third genus,

FIG. 681. *Brasenia peltata* (Water-shield); the lower flower with the floral envelopes and a part of the stamens removed. 682. A magnified stamen. 683. A magnified carpel. 684. The same, divided lengthwise, showing the ovules attached to the outer or dorsal suture! 685. Section of a carpel, in fruit. 686. A magnified seed, with half the outer integument removed, displaying at the upper extremity the bag which contains the embryo. 687. A magnified section through the middle of the albumen, &c.; bringing to view the minute embryo enclosed in its sac, lying outside of the albumen, which forms the principal bulk of the seed.

Bursera. *Tree*, recently discovered in California, with calyx and corolla not very unlike those of *Sarcocolla*, but without the umbrellalike style. The species of *Sarcocolla* are all Eastern North American. The affinities of the group are unsettled.

712. (nd. *Papaveraceae* *Puppy Family*). Herbs with a milky or colored juice, and alternate leaves without stipules. Calyx of two (rarely three), valvular sepals. Corolla of four to six regular petals. Stamens eight to twenty-four, or numerous. Fruit one-celled, with two to five or numerous parietal placentae, from which the valves often separate in dehiscence. Seeds numerous, with a minute embryo, and copious fleshy and oily albumen. — *Ex.* The Poppy (*Papaver*), the leading representative of this small but important family, is remarkable for the extension of the placenta so as almost to divide



the cavity of the ovary into several cells, and for the dehiscence of the capsule by mere chinks or pores under the edge of the crown

FIG. 698. *Sanguinaria Canadensis* (the Bloodroot). 699 The pod, divided transversely, showing the parietal attachment of the seeds. 700 Longitudinal section of a magnified seed with its large raphide, showing the minute embryo, near the extremity of the albumen. 701. Flower-bud of *Eschscholzia*. 702. The calyptiform calyx detached from the base. 703. Petal of the same.

formed by the radiate stigmas. *Eschscholtzia*, now common in gardens, is remarkable for the expanded apex of the peduncle, and for the union of the two sepals into a *calyptra*, like a candle-extinguisher, which, separating at the base, is thrown off by the expansion of the petals. The colored juice is narcotic and stimulant. That of the Poppy yields *Opium*. That of the Celandine and of the Bloodroot (*Sanguinaria*) is acrid.

752. Ord. *Fumariaceæ* (*Fumitory Family*). Smooth herbs, with brittle stems, and a watery juice, alternate dissected leaves, and no stipules. Flowers irregular. Calyx of two sepals. Corolla of four petals, in pairs; the two outer, or one of them, spurred or sac-like at the base; the two inner, callous and cohering at the apex, including the anthers and stigma. Stamens six, in two parcels opposite the outer petals; the filaments of each set usually more or less united; the middle one bearing a two-celled anther; the lateral, with one-celled anthers. Fruit a one-celled and two-valved pod, or round and indehiscent. Seeds with fleshy albumen and a small embryo.—

Ex. *Fumaria*, *Dicentra* (Fig. 369–374), *Corydalis*.

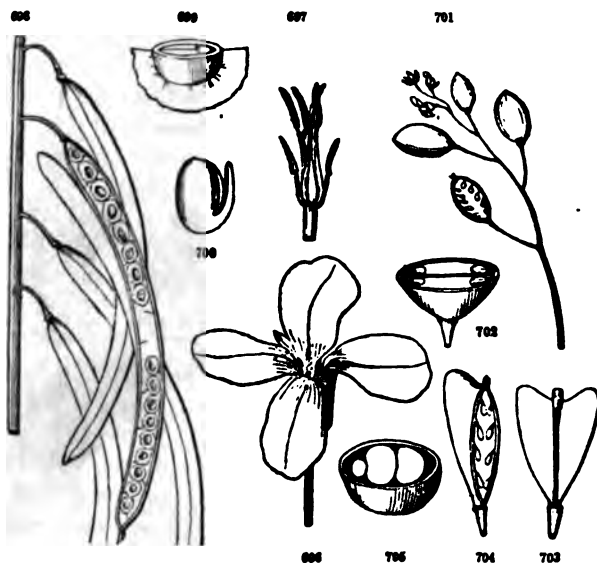
A small and unimportant tribe of plants, chiefly remarkable for their singular irregular flowers; by which, with their watery juice, they are distinguished, and that not very definitely, from the preceding family.

753. Ord. *Cruciferae* (*Mustard Family*). Herbs, with a pungent or acrid watery juice, and alternate leaves without stipules; the flowers in racemes or corymbs, with no bracts to the pedicels. Calyx of four sepals, deciduous. Corolla of four regular petals, with claws, their spreading limbs forming a cross (Fig. 694). Stamens six, two of them shorter (*tetradynamous*, Fig. 695, 589). Fruit a pod (called a *siliqua* when much longer than broad, or a *silicle* when short, Fig. 703), which is two-celled by a membranous partition that unites the two marginal placentæ, from which the two valves usually fall away. Seeds with no albumen: embryo with the cotyledons folded on the radicle.—*Ex.* The Water-Cress, Radish, Mustard, Cabbage, &c. A very natural order, perfectly distinguished by having six tetradynamous stamens along with four petals and four sepals, and by the



FIG. 694. Flower of Mustard. 695. The stamens and pistil.

peculiar pod. The peculiarity of the stamens is explained, and the singular symmetry of the flower illustrated, on p. 243. All these plants have a peculiar volatile acridity (and often an ethereal oil, which abounds in sulphur) dispersed through every part, from which they derive their peculiar odor and sharp taste, and their stimulant, rubefacient, and antiscorbutic properties. The roots of some perennial species, such as the Horseradish, or the seeds of annual species, as the Mustard, are used as condiments. In some cultivated plants, the acrid principle is dispersed among abundance of saccharine and mucilaginous matter, affording wholesome food; as the root of the Turnip and Radish, and the leaves and stalks



of the Cabbage and Cauliflower. None are really poisonous plants, although some are very acrid. Several species are in

FIG. 696. A Cruciferous flower. 697. The same, with the calyx and corolla removed, showing the tetradynamous stamens. 698. *Siliques* of *Arabis Canadensis*; one of them with one of the valves detached, showing the seeds lying on the false partition; the other valve also falling away. 699. A magnified cross-section of one of the winged seeds, showing the embryo with the radicle applied to the edge of the cotyledons (*cotyledons accumbent*). 700. The embryo detached. 701. The raceme of *Draba verna*, in fruit. 702. A cross-section of one of the *sili-cles*, magnified, exhibiting the parietal insertion of the seeds, and the false partition. 703. A silicle of Shepherd's Purse (*Capsella Bursa Pastoris*). 704. The same, with one of the boat-shaped valves removed, presenting a longitudinal view of the narrow partition, &c. 705. A magnified cross-section of one of the seeds, showing the embryo with the radicle applied to the side of the cotyledon (*cotyledons incumbent*).

cultivation, for their beauty or fragrance; such as the Wall-flower, Stock, &c.

754. Ord. *Capparidaceæ* (*Caper Family*). Herbs, or in the tropics often shrubs or trees; differing from *Cruciferae* in the one-celled pod (which is often stalked) being destitute of any false partition; in the kidney-shaped seeds; and in the stamens, which, when six, are scarcely tetradynamous, and are often more numerous. — *Ex.* *Cleome*, *Polanisia*, *Gynandropsis*; chiefly tropical or subtropical. Many have the pungency of *Cruciferae*, but are more acrid. *Capers* are the pickled flower-buds of *Capparis spinosa* of the Levant, &c. The roots and herbage or bark are bitter, nauseous, and sometimes poisonous.



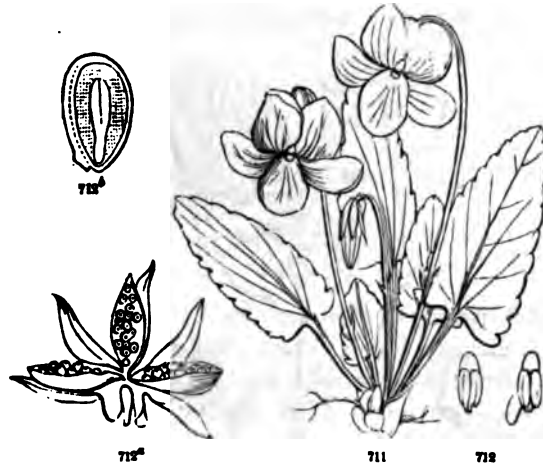
755. Ord. *Resedaceæ* (*Mignonette Family*). Herbs, with a watery juice, and alternate leaves without stipules, except a pair of glands be so considered: the flowers in terminal racemes, small, and often fragrant. — Calyx persistent, of four to seven sepals, somewhat united at the base. Corolla of two to seven usually unequal and lacerated petals, with broad or thickened claws (Fig. 377). A fleshy disk is commonly present, enlarged posteriorly between the petals and the stamens, and bearing the latter, which vary from three to forty in number, and are not covered by the petals and sepals in the bud. Fruit a one-celled pod, with three to six parietal placentæ, three to six-lobed at the apex, where it opens along the

FIG. 706. Flower of *Gynandropsis*. 707. Flower of *Polanisia graveolens*. 708. Fructified ovary of the same, a portion cut away by a vertical and horizontal section, to show the single cell and two parietal placentæ. 709. Cross-section of the ovary. 710. Section of the seed and embryo.

inner sutures, usually long before the seeds are ripe. Seeds several or many, curved or kidney-shaped, with no albumen; the embryo incurved. — *Ex.* The common representatives of this order are the Mignonette (*Reseda odorata*), prized for its fragrant flowers, and the Weld (*R. Luteola*), which yields a poor dye.

756. Ord. *Flacourtiaceæ*, a group of tropical shrubs and trees, placed in this vicinity, is best known by *Bixa Orellana*, which yields *Arnatto*, the orange-red dried pulp of the pod, surrounding the seeds.

757. Ord. *Violaceæ* (*Violet Family*). Herbs (in tropical countries sometimes shrubby plants), with mostly alternate simple leaves, on petioles, furnished with stipules; and irregular flowers (Fig. 396, 397). Calyx of five persistent sepals, often auricled at the base. Corolla of five unequal petals, one of them larger than the others and commonly bearing a spur or a sac at the base: æstivation imbricate.



cative. Stamens five, with short and broad filaments, which are usually elongated beyond the (adnate introrse) anthers; two of them commonly bearing a gland or a slender appendage which is concealed in the spur of the corolla: the anthers approaching each other, or united in a ring or tube. Style usually turned to one side

FIG. 711. *Viola sagittata*. 712. One of the stamens without appendage, seen from within; and one furnished with a spur-like appendage on the back. 712a. A capsule which has opened and separated into three valves; the calyx still persistent. 712b. A vertical section of the seed and embryo.

and thickened at the apex. Fruit a one-celled capsule, opening by three valves, each bearing a parietal placenta on its middle. Seeds several or numerous, anatropous, with a crustaceous integument, and a straight embryo, nearly the length of the fleshy albumen (Fig. 604, 605). — *Ex.* The Violet is the principal genus of this order; some species, like the Pansy, are cultivated for the beauty of their flowers; others, for their delicate fragrance. The roots of all are acrid, and emetic. Those of some South American species of *Ipécacuanha* of commerce.

758. Ord. Cistaceæ (*Rock-Rose Family*). Low shrubby plants or herbs, with simple and entire leaves (at least the lower opposite). Calyx of five persistent sepals; the three inner with a convolute aestivation; the two outer small or sometimes wanting. Corolla of five, or rarely three, regular petals, convolute in aestivation in the direction contrary to that of the sepals, often crumpled, usually ephemeral, sometimes wanting, at least a portion of the flowers. Stamens few or numerous, distinct, with short innate anthers. Fruit



a one-celled capsule with parietal placentæ, or imperfectly three to five-celled by dissepiments arising from the middle of the valves (dehiscence therefore loculicidal), and bearing the placentæ at or near the axis. Seeds few or numerous, mostly orthotropous, with mealy

FIG. 713. The Rock-Rose, *Helianthemum Canadense*. 714. Flower from which the petals and stamens have fallen. 715. Magnified cross-section of the ovary; with a single stamen, showing its hypogynous insertion. 716. Cross-section of a capsule, loculicidally dehiscent; the seeds therefore borne on the middle of each valve. 717. An ovule. 718. Plan of the flower. 719. Section of a seed, showing the curved embryo.

albumen. Embryo curved, or variously coiled or bent. — *Ex.* *Cistus*, *Helianthemum*: a small family; the flowers often showy. No important properties. Several exude a balsamic resin, such as *Ladanum* from a *Cistus* of the Levant.

759. Ord. *Droseraceæ* (*Sundew Family*). Small herbs, growing in swamps, usually covered with gland-bearing hairs; with the leaves rolled up from the apex to the base in veneration (circinnate): stipules none, except a fringe of hairs or bristles at the base of the petioles. Calyx of five equal sepals, persistent. Corolla of five regular petals, withering and persistent, convolute in aestivation. Stamens as many as the petals and alternate with them, or sometimes two or three times as many, distinct, withering; anthers extrorse. Styles three to five, distinct or nearly so, and each two-parted (so as to be taken for ten styles, Fig. 510), and these divisions sometimes two-lobed or many-cleft at the apex. Fruit a one-celled capsule, opening loculicidally by three to five valves, with three to five parietal placentæ; in *Dionæa* membranaceous, bursting irregularly, and with a thick placenta at the base. Seeds usually numerous. Embryo small, at the base of cartilaginous or fleshy albumen. — *Ex.* *Drosera*, the Sundew; and *Dionæa* (Venus's Fly-trap, Fig. 297, 298), so remarkable for its sensitive leaves, which suddenly close when touched. The styles of the latter are all united into one.

760. Ord. *Parnassiaceæ* is for the present made for the genus *Parnassia*, which was formerly appended to *Droseraceæ* (for no good reason), and has since been placed by some next to *Hypericaceæ*, by others referred to *Saxifragaceæ*. It is remarkable for having the four or five stigmas situated directly over the parietal placentæ (p. 294, note), and for the curious appendages resembling sterile stamens before each petal (Fig. 380, 381).

761. Ord. *Hypericaceæ* (*St. Johnswort Family*). Shrubs or herbs, with a resinous or limpid juice, and opposite entire leaves, destitute of stipules, and punctate with pellucid or blackish dots. Flowers regular. Calyx of four or five persistent sepals, the two exterior often smaller. Petals four or five, convolute in aestivation, often beset with black dots. Stamens commonly polyadelphous and numerous. Ovary one-celled with parietal placentæ, or 4–5-celled (Fig. 375, 497, 498, 503, 509). Capsule with septicidal dehiscence (Fig. 582), many-seeded. — *Ex.* *Hypericum* (St. Johnswort) is the type of this small family. Embryo straight; albumen little or none.

The plants yield a resinous acrid juice, and a bitter, balsamic extractive matter.



762. Ord. *Elatinaceæ* (*Waterwort Family*). Small annual weeds with membranaceous stipules between the opposite leaves, and minute axillary flowers. Sepals and petals three to five. Stamens as many or twice as many as the petals, distinct. Capsule 2–5-celled, septicidal or septifragal; the numerous seeds attached to a persistent central axis. Albumen none. — *Ex.* *Elatine* is the type of this order, containing a few insignificant weeds.

763. Ord. *Caryophyllaceæ* (*Pink Family*). Herbs, with opposite entire leaves; the stems tumid at the nodes. Flowers regular. Calyx of four or five sepals. Corolla of four or five petals, or sometimes wanting. Stamens as many, or commonly twice as many, as the petals, sometimes reduced to two or three. Styles two to five, stigmatose down the inside. Ovary mostly one-celled, with a central or basilar placenta, forming a pod in fruit. Embryo peripheric, curved or coiled around the outside of mealy albumen (Fig. 620, 621, 726). — There are five principal suborders, viz.:—

764. Subord. *Sileneæ* (*Pink Family proper*); in which the sepals are united into a tube, and the petals (mostly convolute in æstivation) and stamens are inserted on the stipe of the ovary, the former with long claws (Fig. 432, 449), and there are no stipules. — *Ex.* *Silene*, *Dianthus* (*Pink*, *Carnation*).

765. Subord. *Alsineæ* (*Chickweed Family*); in which there are no

FIG. 720. *Hypericum perforatum* (St. Johnswort). 721. Its tricarpeillary pistil. 722. Cross-section of the capsule. 723. Vertical section of a seed and its embryo.

stipules, the ovary is sessile, the sepals and petals (imbricated in aestivation) are nearly or quite distinct; the petals destitute of claws; and the stamens are inserted into the margin of a small hypogynous disk, which, however, occasionally coheres with the base of the calyx, and becomes perigynous. — *Ex.* *Stellaria*, *Arenaria*, &c. (Chick-

weeds). Some are ornamental; others, such as the common Chickweed, are insignificant weeds.

766. Subord. *Illecebreæ* (*Knotwort Family*); differing from the last mainly in having scarious stipules; the sepals often united below; the petals often wanting or rudimentary; the stamens manifestly perigynous; and the fruit more commonly

a one-seeded utricle — *Ex.* *Paronychia* and *Anychia*. *Spergula* has conspicuous petals, and many-seeded capsules; and so differs from *Alsineæ* only in its stipules. Insignificant weeds.

767. Subord. *Scleranthææ* (*Knawel Family*) is like the last, only there are no stipules. — *Ex.* *Scleranthus*.

768. Subord. *Molluginææ* (*Carpet-weed Family*) is apetalous without stipules, and has the stamens alternate with the sepals when of the same number; thus effecting a transition to

769. Ord. *Portulacacææ* (*Purslane Family*). Succulent or fleshy herbs, with entire exstipulate leaves and usually ephemeral flowers. Calyx mostly of two or three sepals, sometimes cohering with the base of the ovary. Petals five, or rarely more numerous, sometimes none. Stamens variable in number, but when equal to the petals situated opposite them. Styles two to eight, united below. Capsule

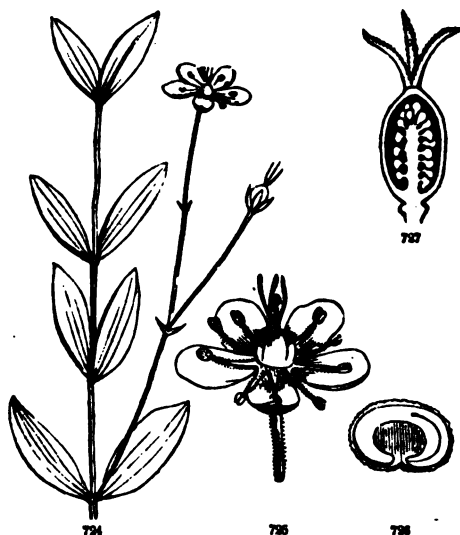
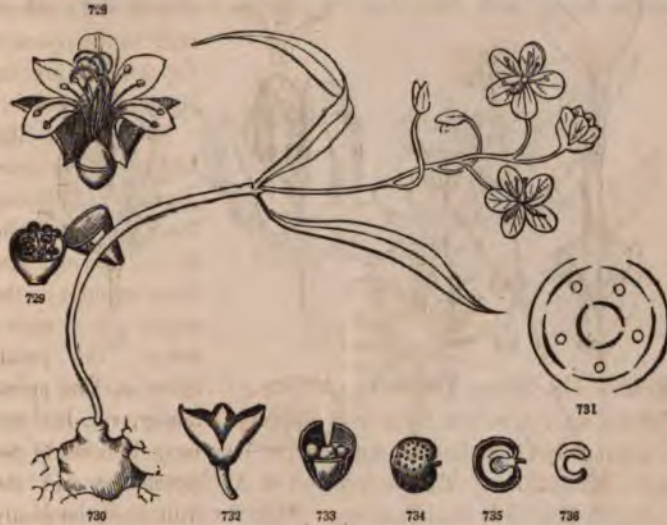


FIG. 724. *Moehringia lateriflora*. 725 A magnified flower. 726. Magnified section of a seed, showing the embryo coiled into a ring around the albumen. 727. Vertical section of a pistil of *Spergularia*.

with few or numerous seeds, attached to a central basilar placenta, often by slender funiculi. Seed and embryo as in Caryophyllaceæ. — *Ex.* *Portulaca* (Purslane, Fig. 389, 588) *Claytonia*. Chiefly natives of dry places in the warmer parts of the world; except *Claytonia*. Insipid or slightly bitter: several are pot-herbs, as the Purslane. Some are ornamental. The farinaceous root of *Lewisia*



rediviva, a native of the dry interior plains of Oregon, is an important article of food with the natives.

770. Ord. *Mesembryanthemaceæ* (*Fig-Marigold Family*) consists of succulent plants, with showy flowers opening only under bright sunshine, containing an indefinite number of petals and stamens, and a many-celled and many-seeded capsule: otherwise much as in Caryophyllaceæ. — *Ex.* *Mesembryanthemum* (*Fig-Marigold, Ice-plant*); chiefly natives of the Cape of Good Hope, flourishing in the most arid situations.

771. Ord. *Malvaceæ* (*Mallow Family*). Herbs, shrubs, or rarely trees. Leaves alternate, palmately veined, with stipules. Flowers regular, often with an involucrel, forming a double calyx. Calyx mostly of five sepals, more or less united at the base, valvate in

FIG. 728. Flower of the Purslane; the calyx cut away at the point where it adheres to the ovary, and laid open. 729. A capsule (pyxis) of the same, transversely dehiscent. 730. *Claytonia virginica* (*Spring-Beauty*). 731. Diagram of the flower. 732. Young fruit and the persistent two-leaved calyx. 733. Section of the dehiscing capsule. 734. A seed. 735. The same, vertically divided. 736. The embryo, detached.

æstivation. Petals as many as the sepals, convolute in æstivation, hypogynous. Stamens indefinite, monadelphous, united with the claws of the petals: anthers reniform, confluent one-celled. Pollen hispid (Fig. 483). Ovary several-celled, with the placentæ in the axis; or ovaries several. Fruit capsular, or the carpels separate or separable. Seeds with a little mucilaginous or fleshy albumen. Embryo large, with foliaceous cotyledons, variously incurved or



folded. — *Ex.* *Malva* (Mallow), *Althæa* (Hollyhock), *Gossypium* (Cotton), &c.: a rather large and important family, the herbage, &c. commonly abounding in mucilage, and entirely destitute of unwholesome qualities. The unripe fruit of *Abelmoschus* or *Hibiscus esculentus* (Okra) is used in soups. *Althæa officinalis* is the Marsh Mallow of Europe, the Guimauve of the French. The tenacious inner bark of many species is employed for cordage. Cotton is the hairy covering of the seeds of *Gossypium*: the long and slender tubes, or attenuated cells, collapse and twist as the seed ripens, which renders the substance capable of being spun. Cotton-seed yields a good fixed oil. Some species are cultivated for ornament.

772. *Ord. Byttneriaceæ* is distinguished from the foregoing by its usually definite stamens, and the two-celled anthers (the cells parallel), with smooth pollen. — A *Melochia* and a *Hermannia* are found in Texas. The rest of the order is tropical or subtropical. *Chocolate* is made of the roasted and comminuted seeds of *Theobroma Cacao* (a South American tree), mixed with sugar, arnotto, vanilla, and other ingredients. The roasted integuments of the seeds, also, are used as a substitute for coffee.

FIG. 737. The Marsh Mallow (*Althæa officinalis*). 738. One of the kidney-shaped one-celled anthers, magnified. 739. The pistil, magnified. 740. Capsule of *Hibiscus Moscheutos*, with the persistent calyx and involucre. 741. The same, locally deciduous.

773. Ord. Sterculiaceæ, very closely allied to the last two, and consisting of tropical trees, possesses the same mucilaginous properties (as well as oily seeds), with which bitter and astringent qualities are often combined. The seeds of *Bombax*, the Silk-cotton tree, are enveloped in a kind of cotton, which belongs to the endocarp and not to the seed; and the hairs, being perfectly smooth and even, cannot be spun. Canoes are made from the trunk of the huge *Bombax Ceiba*, in the West Indies. To this order belongs the famous Baobab, or Monkey-bread, of Senegal (*Adansonia digitata*), some trunks of which are from sixty to eighty feet in circumference! The fruit resembles a gourd, and serves for vessels; it contains a subacid and refrigerant, somewhat astringent pulp; the mucilaginous young leaves are also used for food in time of scarcity; the dried leaves (*Lalo*) are ordinarily mixed with food, and the bark furnishes a coarse thread, which is made into cordage or woven into cloth. *Cheirostemon platanoides* is the remarkable Hand-flower tree of Mexico. A plant of the family (*Fremontia*, Torr.) nearly allied to *Cheirostemon* has been found in California, by Fremont.

774. Ord. Tiliaceæ (*Linden Family*). Trees or shrubby plants, with alternate leaves, furnished with deciduous stipules, and small



flowers. Calyx deciduous. Petals sometimes imbricated in æstiva-

FIG. 742. Flowering branch of *Tilia Americana*, the common American Linden; the flower-stalk cohering with the bract. 743. One of the clusters of stamens adhering to the petaloid scale. 744. The pistil. 745. Cross-section of the fruit, which has become one-celled by the obliteration of the partitions, and one-seeded. 746. Vertical section of the seed, magnified, to show the large embryo with its taper radicle and foliaceous crumpled cotyledons. (A better section of the seed, cut in the direction across the cotyledons, is shown in Fig. 599.) 747. Diagram of the flower.

tion. Stamens indefinite, often in three to five clusters, distinct or somewhat united, one of each parcel often transformed into a petaloid scale (Fig. 383, 743): anthers two-celled. Styles united into one. Fruit two to five-celled, or, by obliteration, one-celled when ripe. In other respects nearly as in *Malvaceæ*. — *Tilia*, the Linden, or Lime-Tree, represents the order in northern temperate regions; the other genera are tropical. All are mucilaginous, with a tough fibrous inner bark. From this *bast* or *bass* of the Linden, the Russian mats, &c. are made, whence the name of Basswood. Gunnybags and fishing-nets are made in India from the bark of *Cochlorus capsularis*; the fibre of which, called *Jute*, is spun and woven. The light wood of the Linden is excellent for wainscoting and carving: its charcoal is used for the manufacture of gunpowder. It is said that a little sugar may be obtained from the sap: and the honey made from the odorous flowers is thought to be the finest in the world. The acid berries of *Grewia sapida* are employed in the East in the manufacture of sherbet.

775. Ord. *Dipterocarpeæ*, allied in some respects to *Tiliaceæ*, consists of a few tropical Indian trees, with a resinous or balsamic juice. *Dryobalanops aromatica*, a large tree of Sumatra and Borneo, yields in great abundance *camphor oil* and solid *camphor*: both are found deposited in cavities of the trunk. It is more solid than common camphor, and is not volatile at ordinary temperatures. It bears a high price, and is seldom found in Europe or this country, but is chiefly carried to China and Japan. *Shorea robusta* yields the *Dammer-pitch*. *Vateria Indica* exudes a kind of copal, the *Gum Animi* of commerce; and a somewhat aromatic fatty matter, called *Piney Tallow*, is derived from the seeds.

776. Ord. *Guttiferæ*, or *Clusiaceæ*, consists of tropical trees, with a yellow resinous juice, opposite and coriaceous entire leaves, and large flowers with many stamens, little distinction between the sepals and petals, no styles, an indehiscent fruit, and seeds with a peculiar undivided fleshy embryo. It has been associated with *Hypericaceæ*, but is more related to the ensuing families. The resinous juice is acrid and drastic; that of a Ceylonese tree of the order yields *Gamboge*. It is remarkable that such an order should produce the same kind of fruits, viz. the *Mangosteen*, yielded by *Garcinia* (Malacca, and also the Mammee-apple, &c. *Camellia* or *Tea Family*). Trees or shrubs, alternate simple leaves without stipules, and

large and showy flowers. Calyx of three to seven coriaceous and concave imbricated sepals. Petals five or more, imbricated in aestivation. Stamens hypogynous, indefinite, monadelphous or polyadelphous at the base. Capsule dehiscent, several-celled, usually with a central column. Seeds few in each cell, large, often winged, with or without albumen.—The Camellia and the closely related Teaplant form the type of this family, to which belong our Gordonia and Stuartia. The leaves of *Tea* contain a peculiar extractive matter, and an ethereal oil; its moderately stimulant properties are said to become narcotic in very hot climates.

778. Ord. Ternstroemiaceæ, chiefly tropical, with which the last has been confounded, by its aspect, its commonly polygamous flowers, and more or less gamopetalous corolla, &c., appears on the whole to be more allied to the Ebenaceæ and Symplocineæ.

779. Ord. Aurantiaceæ (*Orange Family*). Trees or shrubs, with alternate leaves (compound, or with jointed petioles), destitute of stipules, dotted with pellucid glands full of volatile oil. Flowers fragrant. Calyx short, urceolate or campanulate. Petals three to five. Stamens inserted in a single row upon a hypogynous disk (Fig. 434), often somewhat monadelphous or polyadelphous. Style cylindrical. Fruit a many-celled berry, with a leathery rind, filled with pulp. Seeds without albumen.—*Ex.* Citrus, the Orange and Lemon. Nearly all natives of tropical Asia; now dispersed throughout the warmer regions of the world, and cultivated for their beauty and fragrance, and for their grateful fruit. The acid of the Lemon, Lime, &c. is the citric and the malic. The rind abounds in a volatile oil (such as the *Oil of Bergamot* from *C. Limetta*), and an aromatic, bitter principle.

780. Ord. Meliaceæ. Trees or shrubs, with alternate, usually compound leaves, destitute of stipules. Calyx of three to five sepals. Petals three to five. Stamens twice as many as the petals, monadelphous, inserted with the petals on the outside of an hypogynous disk; the anthers included in the tube of filaments. Ovary several-celled, with one or two ovules in each cell: styles and stigmas united into one. Fruit a drupe, berry, or capsule; the cells one-seeded. Seeds without albumen, wingless.—*Ex.* *Melia Azedarach* (*Pride of India*), naturalized, as an ornamental tree, in the Southern States. An acrid and bitter principle pervades this tropical order.

781. Ord. Cedrelaceæ (*Mahogany Family*). Trees (tropical or Australian), with hard and durable, usually fragrant and beautiful

wood; differing botanically from *Meliaceæ* chiefly by their capsular fruit, with several winged seeds in each cell. — *Ex.* The *Mahogany* (*Swietenia Mahagoni*) of tropical America, reaching to East Florida. Bark, &c. bitter, astringent, tonic, often aromatic and febrifugal.

782. Ord. *Linacæ* (*Flax Family*). Herbs, with entire and sessile leaves, either alternate, opposite, or verticillate, and no stipules, except minute glands. Flowers regular and symmetrical. Calyx of three or five persistent sepals, strongly imbricated. Petals as many as the sepals, convolute in æstivation. Stamens as many as the petals, and usually with as many intermediate teeth representing an abortive series (Fig. 423), all united at the base into a ring, hypog-



748



749

nous. Ovary with as many styles and cells as there are sepals, each cell with two suspended ovules; the cells in the capsule each more or less divided into two, by a false partition which grows from the back (Fig. 750); the spurious cells one-seeded. Embryo straight: cotyledons flat, fleshy and oily, surrounded by a



750



751



752

thin albumen. — *Ex.* *Linum*, the Flax. The tough woolly fibre of the bark (*flax*) is of the highest importance: the seeds yield a copious mucilage, and the fixed oil expressed from them is applied to various uses in the arts. The general plan of the flower is the same in the succeeding orders.

FIG. 748. Flowers of the common Flax. 749. Vertical section of a flower. 750. Diagram of the same, in a transverse section. 751. Its 10-celled capsule transversely divided. 752. Similar section of the incompletely 10-celled capsule of *Linum perenne*.

783. Ord. Geraniaceæ (*Cranesbill Family*). Herbs or shrubby plants, commonly strong-scented; with palmately veined and usually lobed leaves, mostly with stipules; the lower opposite. Flowers regular. — Calyx of five persistent sepals, imbricated in æstivation. Petals five, with claws, mostly convolute in æstivation. Stamens 10, the five exterior hypogynous, occasionally sterile; the filaments all broad and often united at the base; five glands within and alternate with the petals. Ovary of five two-ovuled carpels, attached to the base of an elongated axis (*gynobase*, Fig. 430, 431) to which the styles cohere: in fruit the distinct one-seeded carpels separate from the axis, by the twisting or curling back of the persistent indurated



styles from the base upwards. Seeds with no albumen: cotyledons convolute and plaited together, bent on the short radicle. For the plan of the blossom see p. 264, and Fig. 421. Our cultivated *Geraniums*, so called, from the Cape of Good Hope, are species of *Pelargonium*. The roots are simply and strongly astringent. The foliage abounds with resinous matter and an ethereal oil, on which the aroma depends.

784. Ord. *Balsaminaceæ* (*Balsam Family*). Annual herbs, with succulent stems filled with a watery juice. Leaves simple, without stipules. Flowers irregular, and one of the colored sepals spurred or saccate. Stamens five, cohering by an internal appendage.

FIG. 753. Radical leaf of *Geranium maculatum* (*Cranesbill*). 754. A flowering branch. 755. A flower with the calyx and corolla removed, showing the stamens, &c. 756. The pistil in fruit; the indurated styles separating below from the prolonged axis, and curving back elastically, carrying with them the membranous carpels. 757. A magnified seed. 758. A cross-section of the same, showing the folded and convolute cotyledons.

Compound ovary five-celled; stigmas sessile. Capsule bursting elastically by five valves. Seeds several, without albumen, and with a thick straight embryo. — *Ex.* Impatiens, the Balsam, or Touch-me-not. Remarkable for the elastic force with which the capsule bursts in pieces, and expels the seeds. Somewhat differently irregular blossoms are presented by the

785. Ord. *Tropæolaceæ* (*Indian-Cress or Nasturtium Family*). Straggling or twining herbs, with a pungent watery juice, and peltate or palmate leaves. Flowers irregular. Calyx of five colored and united sepals, the lower one spurred. Petals five; the two upper arising from the throat of the calyx, remote from the three lower, which are stalked. Stamens eight, unequal, distinct. Ovary three-lobed, composed of three united carpels; which separate from the common axis when ripe, are indehiscent, and one-seeded. Seed filling the cell, without albumen: cotyledons very large and thick. — *Ex.* Tropæolum, the Garden Nasturtium, from South America, where there are a few other species, one of which bears edible tubers. They possess the same acrid principle and antiscorbutic properties as the Cruciferae. The unripe fruit of Tropæolum majus is pickled, and used as a substitute for capers.

786. Ord. *Limnanthaceæ* differs from the last only in its regular and symmetrical blossoms, and the erect instead of suspended seeds; the calyx valvate in æstivation. — *Ex.* Limnanthes of California (sometimes cultivated as an ornamental annual), and Flœrkea of the Northern United States.

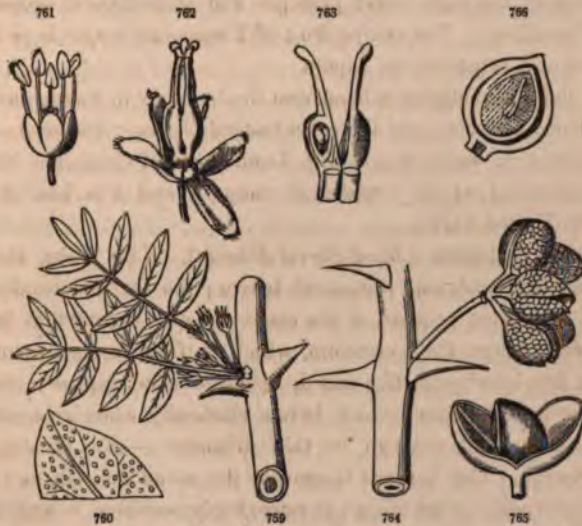
787. Ord. *Oxalidaceæ* (*Wood-Sorrel Family*). Low herbs, with an acid juice, and alternate compound leaves; the leaflets usually obcordate. Flowers regular, of the same general structure as in Linaceæ, &c., except the gynæcium, which in fruit forms a membranaceous five-lobed and five-celled, several-seeded capsule. Seeds with a fleshy outer coat, which bursts elastically when ripe, with a large and straight embryo in thin albumen. — *Ex.* Oxalis, the Wood-Sorrel. The herbage is sour, as the name denotes, and contains oxalic acid. The foliage is remarkably sensitive in some species. The tubers of some South American species, filled with starch, have been substituted for potatoes.

788. Ord. *Zygophyllaceæ* differs from the last in the opposite, mostly abruptly pinnate leaves, distinct stamens (the filaments commonly furnished with an internal scale, Fig. 379), and the styles united into one. — *Ex.* Tribulus and Kallstroemia (introd

the Southern States) are exalbuminous; the latter is 10-cocepus, just as *Linum* is, by a false partition. *Guaiacum*, *Larrea* (Creosote-plant of New Mexico and Texas), and the rest of the family, have a corneous albumen. The wood of *Guaiacum* (*Lignum-vitæ*) is extremely hard and heavy, and yields a gum-resinous, bitter, and acrid principle (*Gum Guaiacum*), well known in medicine.

789. Ord. *Simarubaceæ* (*Quassia Family*), of tropical shrubs or trees, resembles the last in generally having a peculiar scale to the filaments. It is, however, more nearly related to the next order, but its apocarpous ovaries are one-ovuled, and the (mostly compound) leaves are dotless. The wood, &c. is intensely bitter: that of *Quassia amara* is used as a stomachic tonic. The seed of *Cedron* (*Simaba Cedron*) is the famous antidote for the bites of venomous snakes in Central America.

790. Ord. *Rutaceæ* (*Rue Family*). Herbs, shrubs, or trees; the leaves punctate with pellucid dots, and without stipules. Calyx of four or five sepals. Petals four or five, or rarely none. Stamens



as many or twice (rarely three times) as many as the petals, insert-

FIG. 759. A flowering branch of *Zanthoxylum Americanum* (the Northern Prickly Ash). 760. A piece of a leaf, to show the pellucid dots. 761. Staminate flower. 762. A pistillate flower, the sepals spread open. 763. Two of the pistils; one of them divided vertically to show the ovules. 764. A branch in fruit. 765. One of the dehiscent pods, and the seed. 766. Vertical section of an unripe pod and seed; the latter pendent from a descending funiculus, showing a slender embryo in copious albumen.

ed on the outside of a hypogynous disk. Ovary three- to five-lobed, three- to five-celled, with the styles united, or distinct only at the base, or the ovaries nearly separate, during ripening usually separating into its component carpels, which are dehiscent by one or both sutures. Seeds few or single, mostly with albumen; and a curved embryo. — *Ex.* Ruta (the Rue), Dictamnus (Fraxinella), of Europe. Diosma and its allies, of the Cape of Good Hope, New Holland, &c., form a group, or suborder (DIOSMEÆ) from which the ZANTHOXYLÆ (or Prickly-Ash Family) differs only in being generally diœcious; but have no claim to be ranked as a distinct order. Strong-scented, bitter-aromatic, often very pungent, from an acrid volatile oil (as Rue and Zanthoxylum); also bitter. Some contain a bitter alkaloid, and are febrifugal. The most important is the Galipea, which furnishes the *Angostura bark*.

791. Ord. Anacardiaceæ (*Cashew Family*). Trees or shrubs, with a resinous or milky, often acrid juice, which turns blackish in drying; the leaves alternate, without stipules, and not dotted. Flowers small, often polygamous or diœcious. Calyx of three to five sepals, united at the base. Petals, and usually the stamens, as many as the sepals, inserted into the base of the calyx or into an hypogynous disk. Ovary one-celled, but with three styles or stigmas, and a single ovule. Fruit a berry or drupe. Seed without albumen. Embryo curved or bent. — *Ex.* Rhus, Anacardium (the Cashew), Pistacia. Chiefly tropical; except Rhus. The acrid resinous juice is used in varnishes; but it often contains a caustic poison. Even the exhalations from Rhus Toxicodendron (Poison Oak, Poison Ivy), and R. venenata (Poison Sumach, Poison Elder), as is well known, severely affect many persons, producing a kind of erysipelas. Their juice is a good indelible ink for marking linen. But the common Sumachs (R. typhina and R. glabra) are innocuous; their bark or leaves are used for tanning, and their sour berries (which contain bimalate of lime) for acidulated drinks. The oily seeds of Pistacia vera (the Pistachio-nut) are edible; and the drupe of Mangifera Indica (Mango) is one of the most grateful of tropical fruits. The kernel of the Cashew-nut (Anacardium occidentale) is eatable; and so is the enlarged and fleshy peduncle on which the nut rests: but the coats of the latter are filled with a caustic oil, which blisters the skin; while from the bark of the tree a bland gum exudes.

792. Ord. Burseraceæ, including a great part of what were formerly called Terebinthaceæ, consists of tropical trees, with a copious resin-

ous juice, compound leaves usually marked with pellucid dots, and small flowers; with valvate petals, a two- to five-celled ovary, and drupaceous fruit. Their balsamic juice, which flows when the trunk is wounded, usually hardens into a resin. The *Olibanum*, used as a fragrant incense, the *Balm of Gilead*, *Balsam of Mecca*, *Myrrh*, and the *Bdellium*, are derived from Arabian species of the order; the East Indian *Gum Elemi*, from *Canarium commune*; *Balsam of Acouchi*, and similar substances, from various American trees of this family.

793. Ord. Amyridaceæ consists of a few West Indian plants, intermediate as it were between Burseraceæ and Leguminosæ, and distinguished from the former chiefly by their simple and solitary ovary. — Very probably this and the two last are to be recombined.



794. Ord. Vitaceæ (*Vine Family*). Shrubby plants, climbing by tendrils, with simple or compound leaves, the upper alternate.

FIG. 767. A branch of the Grape-Vine. 768. A flower; the petals separating from the base, and falling off together without expanding. 769. A flower from which the petals have fallen; the lobes of the disk seen alternate with the stamens. 770. Vertical section through the ovary and the base of the flower: *a*, calyx, the limb of which is a mere rim: *b*, petal, having the stamen, *c*, directly before it; and the lobes of the disk are shown between this and the ovary. 771. A seed. 772. Section of the seed, showing the thick crustaceous testa, and the albumen, at the base of which is the minute embryo. 772'. A horizontal plan of the flower.

Flowers small, often polygamous or diœcious. Calyx very small, filled with a disk; its limb short or obsolete. Petals 4 or 5, valvate in æstivation, sometimes cohering by their tips, and caducous. Stamens as many as the petals and opposite them! Ovary two-celled, with two erect ovules in each cell. Fruit a berry. Seeds with a bony testa, and a small embryo in hard albumen.—*Ex.* *Vitis* (the Vine), *Ampelopsis* (the Virginia Creeper). The fruit of the Vine is the only important product of the order. The acid of the grape, which also pervades the young shoots and leaves, is chiefly the tartaric. Grape-sugar is very distinct from cane-sugar, and the only kind that can long exist in connection with acids.

795. Ord. *Rhamnaceæ* (*Buckthorn Family*). Shrubs or trees, often with spinose branches; the leaves mostly alternate, simple. Flowers small. Calyx of four or five sepals, united at the base, valvate in æstivation. Petals four or five, cucullate or convolute, inserted on the throat of the calyx, sometimes wanting. Stamens as many as the petals, inserted with and opposite them! Ovary sometimes coherent with the tube of the calyx, and more or less immersed in a fleshy disk, with a single erect ovule in each cell (Fig. 435, 436). Seeds not arilled. Embryo straight, large, in sparing albumen.—*Ex.* *Rhamnus* (Buckthorn) is the type of the order. The berries of most species are somewhat nauseous; but those of *Zizyphus* are edible. *Jujube paste* is prepared from those of *Z. Jujuba* and *Z. vulgaris* of Asia. *Syrup of Buckthorn* and the pigment called *Sap-green* are prepared from the fruit of *Rhamnus catharticus*. The herbage and bark in this order are more or less astringent and bitter. An infusion of the leaves of *Ceanothus Americanus* (thence called New Jersey Tea) has been used as a substitute for tea, and a very poor one it is.

796. Ord. *Celastraceæ* (*Spindle-tree Family*). Shrubs or trees, with alternate or opposite simple leaves. Calyx of four or five sepals, imbricated in æstivation. Petals as many as the sepals, inserted under the flat expanded disk which closely surrounds the ovary, imbricated in æstivation. Stamens as many as the petals, and alternate with them, inserted on the margin or upper surface of the disk. Ovary free from the calyx. Fruit a capsule or berry, with one or few seeds in each cell. Seeds usually arilled, albuminous, with a large and straight embryo.—*Ex.* *Celastrus*, *Euonymus* (Burning Bush, Spindle-tree, Strawberry-tree); all somewhat bitter and acrid; but of little economical importance. The red or crim-

son capsules and bright scarlet arils of several species present a striking appearance when the fruit is ripe.

797. Ord. Malpighiaceæ is a large tropical family (with one or two representatives in Texas), of trees, shrubs, and twining plants, with opposite entire leaves, unguiculate petals, and solitary seeds with a curved embryo; differing from the next in the want of a disk, the more symmetrical flowers, &c.

798. Ord. Sapindaceæ (*Soapberry Family*). Trees, shrubs, or climbers with tendrils, rarely herbs, with simple or compound leaves, and mostly unsymmetrical or irregular flowers; the sepals and petals imbricated in æstivation. Stamens 5 to 10, inserted on a fleshy perigynous or hypogynous disk. Ovary 2-3-celled, 2-3-lobed, with one or two (in *Staphylea* several) ovules in each cell; the embryo (except in *Staphylea*) curved or convolute and without albumen.— Includes a variety of forms, the greater part of which may be ranged under the following suborders, which have been taken for orders.



799. Subord. Staphyleaceæ (*Bladdernut Family*) has opposite compound leaves with stipules and stipels, regular and perfect pentan-

FIG. 773. Flowering branch of *Esculus Pavia* (Red Buckeye). 774. A flower. 775. Flower with the calyx and two of the petals removed. 776. A ground-plan of the flower, showing that its parts are unsymmetrical. 777. Vertical section of an ovary, showing two of the cells with a pair of ovules in each, one ascending, one descending. 778. Cross section of an ovary. 779. Cross-section of the immature fruit; only one fertile seed; the others abortive. 780. The dehiscent fruit.

drous flowers, three partly united pistils with several ovules in each, and large bony seeds, with a straight embryo in scanty albumen. — *Ex. Staphylea.*

800. Subord. Sapindæ (*Soapberry Family proper*) has alternate, or in the Horsechestnut tribe opposite leaves, without stipules, more or less unsymmetrical or irregular and polygamous flowers, exalbuminous seeds, and a curved embryo with thickened cotyledons. — Mostly tropical, except the Horsechestnut and Buckeyes (*Æsculus*), which have been deemed a separate family (*Hippocastanæ*). Their very large and fleshy embryo has the cotyledons more or less consolidated (Fig. 629, 630). The seeds of the Horsechestnut are nutritious, but contain an intensely bitter principle which is more or less noxious. Those of *Æ. Pavia* are used to stupefy fish. The root, according to Elliott, is employed as a substitute for soap. The fruit of *Sapindus* is used for the same purpose, whence the name of *Soapberry*.



801. Subord. Acerinæ (*Maple Family*) has opposite (simple or compound) leaves without stipules, a 2-lobed and 2-winged fruit

FIG. 781. A branch of *Acer dasycarpum* (the White Soft Maple) with staminate flowers. 782. A separate, enlarged, staminate flower. 783. Branch with pistillate flowers. 784. A separate fertile flower. 785. The same, enlarged, with the calyx cut away. 786. A cluster showing the fruiting ovaries expanding into wings (reduced in size). 787. Ripe fruit; one of the samaras cut open to show the seed. 788. A leaf.

forming two samaras, and an embryo with long and thin, variously curved or coiled cotyledons (Fig. 103–105); otherwise nearly as in the true Sapindaceæ. — *Ex.* *Acer*, the Maple; useful timber-trees of northern temperate regions. Sugar is yielded by the vernal sap of *Acer saccharinum*, and in less quantity by all the species.

802. Ord. Polygalaceæ. Herbs or shrubby plants, with simple entire leaves, destitute of stipules. Flowers perfect, unsymmetrical, and irregular, somewhat papilionaceous in appearance, but of widely different structure. Calyx of five irregular sepals; the odd one superior, the two inner (*wings*) larger, and usually petaloid. Petals usually three, inserted on the receptacle, more or less united; the anterior (*keel*) larger than the rest. Stamens six to eight, combined in a tube, which is split on the upper side, and united below with the claws of the petals: anthers innate, mostly one-celled, opening by a pore at the apex. Ovary compound, two-celled, with a single suspended ovule in each cell: style curved and often hooded.



Capsule flattened. Seeds usually with a caruncle. Embryo straight, large, in fleshy, thin albumen. — *Ex.* *Polygala* is the principal genus of the order. The plants yield a bitter principle with some acrid

FIG. 789. *Polygala paucifolia*. 790. A flower, enlarged. 791. The calyx displayed. 792. The corolla and staminal tube laid open. 793. The pistil and the free portion of the stamens. 794. Vertical section of the ovary. 795. Vertical section of the seed, showing the large embryo and scanty albumen.

extractive matter. *Polygala Senega* (Seneca Snakeroot) is the most important medicinal plant of the family. Other species are employed medicinally in Brazil, Peru, Nepaul, &c.; where, like our own, they are reputed antidotes to the bites of venomous reptiles.

803. Ord. *Krameriaceæ* (*Rhatany Family*) consists of the genus *Krameria* only, which has ordinarily been annexed to the *Polygalaceæ*; but the position of the parts of the flower is more like that of the *Leguminosæ*, having the odd sepal inferior, a simple unilocular pistil, and an exalbuminous seed. In fact it is technically distinguishable from the latter chiefly by the hypogynous stamens and the want of stipules. The roots contain a red coloring matter, and are astringent without bitterness. Rhatany-root, used to adulterate portwine, and as an ingredient in tooth-powders, &c., is the produce of *K. triandra* of Peru. That of our own Southern species possesses the same properties.



804. Ord. *Leguminosæ* (*Pulse Family*). Herbs, shrubs, or trees, with alternate and usually compound leaves, furnished with stipules.

FIG. 796. A flowering branch of *Lathyrus palustris*, var. *myrtifolius*. 797. The corolla displayed: *a*, the vexillum or standard; *b*, the alae or wings; *c*, the two petals of the carina or keel. 798. The keel-petals in their natural situation. 799. The stamens and pistil, enlarged; the sheath of filaments partly turned back.

Calyx mostly of five sepals, more or less united; the odd sepal inferior (Fig. 358). Corolla of five petals, either papilionaceous or regular. Stamens perigynous, or sometimes hypogynous. Ovary single and simple. Fruit a legume, various forms of which are shown in Fig. 580, 581, 800–807. Seeds destitute of albumen, or with a mere vestige of it.—This immense family is divided into three principal suborders; viz.:—



805. Subord. Papilionaceæ (*Pulse Family proper*), which is characterized by the papilionaceous corolla,—the vexillum always external in æstivation (471, Fig. 392),—ten diadelphous (Fig. 461), monadelphous (Fig. 462), or rarely distinct, perigynous stamens, and the radicle bent on the large cotyledons. Leaves (rarely simple) only once compound; the leaflets very rarely toothed or lobed.

806. Subord. Cæsalpinieæ (to which Cassia, Cercis, and the Honey-Locust belong): here the corolla gradually loses its papilionaceous character, and always has the vexillum, or superior petal, covered by the lateral ones in æstivation; the stamens are distinct, and the embryo straight. The leaves are often bipinnate.

807. Subord. Mimoseæ (a large group, to which the Acacia and the Sensitive Plant belong) has a perfectly regular calyx and corolla, the latter mostly valvate in æstivation and hypogynous, as well as the stamens, which are sometimes definite, but often very numerous; and the embryo is straight. The leaves are frequently tripinnate.

FIG. 800. Open legume of the Pea. 801. Loment of Desmodium. 802. Loment of Mimosa: *b*, one of its dehiscent joints which has fallen away from the persisting border or frame (replum), seen in 803. 804. The jointed indehiscent legume of Sophora. 805. A legume of Astragalus, cut across near the summit, to show how it becomes partly or entirely two-celled by the introflexion of the dorsal suture. 806. Similar view of a legume of Phaca, where the ventral suture is somewhat introflexed. 807. A legume of Medicago scutellata, spirally coiled into a globular figure.

808. Papilionaceæ are found in every part of the world: Cæsalpineæ and Mimoseæ are confined to the tropical and warmer temperate regions. — A full account of the useful plants and products of this large order would require a separate volume. Many, such as Clover, Lucerne (*Medicago sativa*), &c., are extensively cultivated for fodder; Peas and Beans, for pulse. The roots of the Licorice (*Glycyrrhiza glabra* of Southern Europe) abound in a sweet mucilaginous juice, from which the pectoral extract of this name is prepared. The sweet pulp of the pods of *Ceratonia Siliqua* (Carob-tree of the South of Europe, &c.), like that of the Honey-Locust (*Gleditschia*), &c., is edible. The laxative pulp of *Cathartocarpus Fistula*, and of the Tamarind, is well known; the latter is acidulated with malic, and a little tartaric and citric acid. — A peculiar volatile principle (called *Coumarin*) gives its vanilla-like fragrance to the well-known *Tonka-bean*, and to the *Melilotus*, or Sweet Clover. The flowers and seeds of the latter and of *Trigonella cærulea* give the peculiar odor to *Scheipzeiger* cheese. — Astringents and tonics are also yielded by this order: such as the African *Pterocarpus erinaceus*, the hardened red juice of which is *Gum Kino*; that of *P. Draco*, of Carthage, &c., is *Dragon's Blood*. The bark of most Acacias and Mimosas contains a very large quantity of tannin, and is likely to prove of great importance in tanning. The valuable astringent called *Catechu* is obtained by boiling and evaporating the heart-wood of the Indian Acacia *Catechu*. — Leguminosæ yield the most important coloring matters: such as the *Brazil-wood*, the *Logwood* of Campeachy (the peculiar coloring principle of which is called *Hæmatin*), and the *Red Sandal-wood* of Ceylon. *Indigo* is prepared from the fermented juice of the *Indigofera tinctoria* (a native of India), and other species of the genus. This substance is highly azotized, and is a violent poison. — To the same order we are indebted for valuable resins and balsams; such as the Mexican *Copal*, *Balsam of Copaiva* of the West Indies, Para, and Brazil, the bitter and fragrant *Balsam of Peru*, and the sweet, fragrant, and stimulant *Balsam of Tolu*. — It also furnishes the most useful gums; of which we need only mention *Gum Tragacanth*, derived from *Astragalus verus* of Persia, &c.; and *Gum Arabic*, the produce of certain African species of Acacia. The best is said to be obtained from *Acacia vera*, while *Gum Senegal* is yielded by *A. Verrek*, and some other species. *Algarobia dulcis*, the Mesquite of Texas and Mexico, yields a similar gum. The *Senna* of

commerce consists of the leaves of several species of Cassia, of Egypt and Arabia. *C. Marilandica* of this country is a succedaneum for the officinal article. — More acrid, or even poisonous properties, are often met with in the order. The roots of *Baptisia tinctoria* (called Wild Indigo, because it is said to yield a little of that substance), of the Broom, and of the Dyers' Weed (*Genista tinctoria*, used for dyeing yellow), possess such qualities; while the seeds of *Laburnum*, &c. are even narcotico-acrid poisons. The branches and leaves of *Tephrosia*, and the bark of the root of *Piscidia Erythrina* (Jamaica Dogwood, which is also found in Southern Florida), are commonly used in the West Indies for stupefying fish. *Cowitch* is the stinging hairs of the pods of species of *Mucuna*. — Among the numerous valuable timber-trees, our own Locust (*Robinia Pseudacacia*) must be mentioned; and also the Rosewood of commerce, the produce of some Brazilian *Caesalpinieæ*. Few orders furnish so many plants cultivated for ornament.

809. Ord. *Rosaceæ* (*Rose Family*). Trees, shrubs, or herbs, with alternate leaves, usually furnished with stipules. Flowers regular. — Calyx of five (rarely three or four) more or less united sepals, and often with as many bracts. Petals as many as the sepals (rarely none), mostly imbricated in æstivation, perigynous. Stamens indefinite, or sometimes few, distinct. Ovaries with solitary or few ovules: styles often lateral. Albumen none. Embryo straight, with broad and flat or plano-convex cotyledons (Fig. 108–111). — This important order is divided into four suborders; viz.:—

810. Subord. *Chrysobalanæ* (*Cocoa-plum Family*). This is now generally taken as an independent order, intermediate between *Leguminosæ* and *Rosaceæ*. Ovary solitary, free from the calyx, or else cohering with it at the base on one side only, containing two erect ovules: style arising from the apparent base. Fruit a drupe. Trees or shrubs. — *Ex.* *Chrysobalanus*; some species of which produce an edible fruit.

811. Subord. *Amygdalæ* (*Almond or Plum Family*). Ovary solitary, free from the deciduous calyx, with two suspended ovules, and a terminal style. Fruit a drupe (Fig. 562). Trees or shrubs. — *Ex.* *Amygdalus* (the Almond, Peach), *Prunus* (the Plum), &c.

812. Subord. *Rosaceæ* proper. Ovaries several, numerous, or rarely solitary, free from the calyx (which is often bracteolate, as if double), but sometimes enclosed in its persistent tube, in fruit becoming either follicles or achenia. Styles terminal or lateral. Herbs or

shrubs. — The three tribes of this suborder are : — Tribe 1. SPIRÆÆ, where the fruit is a follicle. *Ex.* Spiræa and Gilleenia. Tribe 2. DRYADEÆ, where the fruits are achenia, or sometimes little drupes, and when numerous crowded on an enlarged torus (Fig. 558, 559, 564, 565). *Ex.* Dryas, Agrimonia, Potentilla, Fragaria (Strawberry), Rubus (Raspberry and Blackberry). Tribe 3. ROSEÆ, where numerous achenia cover the hollow torus which lines the urn-shaped calyx-tube; and the latter, being contracted at the mouth, and becoming fleshy or berry-like, forms a kind of false pericarp; as in the Rose (Fig. 429, 808).

813. Subord. Pomææ (*Pear Family*). Ovaries two to five, or rarely solitary, cohering with each other and with the thickened and fleshy or pulpy calyx-tube; each with one or two (in the Quince several) ascending seeds. Trees or shrubs. — *Ex.* Cratægus (the Thorn), Cydonia (the Quince), Pyrus (the Apple, Pear, &c.).



814. This important order is diffused through almost every part of the world; but chiefly abounds in temperate climates, where it furnishes the most important fruits. It is destitute of unwholesome qualities, with one or two exceptions, viz.: — The bark, leaves, and kernel of Amygdaleæ contain prussic acid, or something of similar odor and analogous properties; as is exemplified by the Cherry-Laurel

FIG. 808. Vertical section of an unexpanded Rose, showing the attachment of the carpels to the lining of the calyx-tube, and of the stamens and petals to its summit or edge. 809. Vertical section of the fruit of the Quince, exhibiting the carpels invested by the thickened calyx which forms the edible part of the fruit; one of the ovaries laid open to show the seeds. 810. A magnified seed; the raphide and chalaza conspicuous. 811. The embryo. 812. Cross-section of an apple. 813. Flower, &c. of the American Crab-apple (*Pyrus coronaria*).

of the Old World, from which the poisonous *Laurel-water* and the virulent *Oil of Laurel* are obtained. Our Southern species, *Prunus* (*Laurocerasus*) *Caroliniana*, poisons cattle which eat its foliage. The root of *Gillenia* (*Bowman's Root*, *Indian Physic*) is emetic in large doses, in small doses it acts as a tonic. The bark and root in all are astringent. The bark of *Amygdaleæ* also exudes gum. That of the Wild Black Cherry is febrifugal; and the timber is useful in cabinet-work. Sweet and bitter almonds are the seeds of varieties of *Amygdalus communis*: the oil of the former resembles olive-oil; that of the latter is poisonous. Of the Peach, Apricot, Nectarine, Plum, and Cherry, it is unnecessary to speak. The strawberry, raspberry, and blackberry are the principal fruits of the proper *Rosaceæ*. The leaves of *Rosa centifolia* are more commonly distilled for *Rose-water*: and *Attar of Roses* is obtained from *R. Damascena*, &c. — Pomaceous fruits, such as the apple, pear, quince, services, medlar, &c., yield to none in importance: their acid is usually the malic.



815. Ord. Calycanthaceæ. A small group of shrubs, between the

FIG. 814. Flowers of *Calycanthus floridus*. 815. Vertical section of a flower, showing the hollow receptacle, &c.; the floral envelopes cut away. 816. A stamen, seen from without. 817. A pistil. 818. Section of the ovary, showing the two ascending ovules. 819. The closed pod-shaped receptacle in fruit. 820. A vertical section of an acheneum, showing the embryo of the seed. 821. Cross-section of an embryo, showing the strongly convolute cotyledons.

last order and the next, distinguished from Rosaceæ by their opposite leaves without stipules, and their convolute cotyledons: the ovaries are enclosed in a fleshy calyx-tube as in a rose-hip. — It comprises only two genera; viz. *Calycanthus* (Carolina Allspice, Sweet-scented Shrub, &c.), and *Chimonanthus*, of Japan. They are cultivated for their fragrant flowers. The bark and foliage exhale a slight camphoric odor; and the flowers give a fragrance like that of strawberries.

816. Ord. *Myrtaceæ* (*Myrtle Family*). Aromatic trees or shrubs, with opposite and simple entire leaves, which are punctate with pellucid dots, and often furnished with a vein running parallel with and close to the margin, without stipules; the calyx-tube adherent to the ovary; many stamens; and seeds without albumen. — *Ex.* *Myrtus*, the Myrtle, is the most familiar representative of this beautiful tropical and subtropical order. The species abound in a pungent and aromatic volatile oil, and an astringent principle. *Cloves* are the dried flower-buds of *Caryophyllus aromaticus*. *Pimento* (Allspice) is the dried fruit of *Eugenia Pimenta*. *Cajeput oil*, a powerful sudorific, is distilled from the leaves and fruit of a *Melaleuca* of the Moluccas. Australian species of *Eucalyptus* yield a large quantity of tannin. The aromatic fruits of many species, filled with sugar and mucilage, and acidulated with a free acid, are highly prized; such, for instance, as the Pomegranate, the Guava, Rose-Apple, &c.

817. Ord. *Melastomaceæ*. Trees, shrubs, or herbs, with opposite ribbed leaves, and showy flowers, with as many or twice as many stamens as petals; the anthers mostly appendaged and opening by pores, inflexed in æstivation: further distinguished from *Myrtaceæ* by the leaves not being dotted; and from *Lythraceæ* by the adnation of the calyx-tube (by its nerves at least) with the ovary. — *Ex.* The beautiful species of *Rhexia* represent this otherwise tropical order in the United States. The berries of *Melastoma* are eatable, and tinge the lips black (like whortleberries); whence the generic name.

818. Ord. *Lythraceæ* (*Loosestrife Family*) is distinguished among these perigynous orders, with exalbuminous seeds, by its tubular calyx enclosing the two-four-celled ovary, but entirely free from it. The styles are perfectly united into one: the fruit is a thin capsule. The stamens are inserted on the tube of the calyx below the petals. — *Ex.* *Lythrum*. Chiefly tropical, of little economical use.

819. Ord. *Rhizophoraceæ* (*Mangrove Family*) consists of a few tropical trees (extending into Florida and Louisiana), growing in maritime swamps, where they root in the mud, and form thickets on the verge of the ocean. The ovary is often partly free from the calyx, two-celled, with two pendulous ovules in each cell. These plants are remarkable for their opposite leaves, with interpetiolar stipules, and for the germination of the embryo while within the pericarp. — *Ex.* *Rhizophora*, the Mangrove (Fig. 141). The astringent bark has been used as a febrifuge, and for tanning.

820. Ord. *Combretaceæ* consists of tropical trees or shrubs (which have one or two representatives in Southern Florida), often apetalous, but with slender colored stamens; distinguishable from any of the preceding orders of this group by their one-celled ovary, with several suspended ovules, but only a solitary seed, and convolute cotyledons. — *Ex.* *Combretum*.

821. Ord. *Onagraceæ* (*Evening-Primrose Family*). Herbs, or rarely shrubby plants, with alternate or opposite leaves, not dotted nor



furnished with stipules. Flowers usually tetramerous. Calyx adherent to the ovary, and usually produced beyond it into a tube.

FIG. 822. Flower of *Gnethera fruticosa*. 823. The same, with the petals removed. 824. Magnified grains of pollen, with some of the intermixed cellular threads. 825. Cross-section of the four-lobed and four-celled capsule.

FIG. 826. *Hippuris vulgaris* (suborder *Haloragaceæ*). 827. Magnified flower, with the subtending leaf. 828. Vertical section of the ovary. 829. Vertical section of the fruit and seed.

Petals usually four (rarely three or six, occasionally absent), and the stamens as many, or twice as many, inserted into the throat of the calyx. Ovary commonly four-celled: styles united. Fruit mostly capsular. — *Ex.* Chiefly an American order; many are ornamental in cultivation. *Fuchsia*, remarkable for its colored calyx and berryed fruit; *Oenothera* (Evening Primrose); *Epilobium*, where the seeds bear a coma; *Ludwigia*, which is sometimes apetalous; and *Circea*, where the lobes of the calyx, petals, stamens, cells of the ovary, and the seeds, are reduced to two; showing a connection with the appended

822. Subord. *Haloragæ*, which are a sort of reduced aquatic *Onagraceæ*, often apetalous; the solitary seeds commonly furnished with albumen. — *Ex.* *Myriophyllum* (Water-Milfoil) and *Hippuris* (Horse-tail), where the limb of the calyx is almost wanting; the petals none; the stamens reduced to a single one, and the ovary to a single cell, with a solitary seed.



823. Ord. *Grossulaceæ* (*Gooseberry Family*). Small shrubs, either spiny or prickly, or unarmed; with alternate, palmately lobed and

FIG. 830. The cultivated Gooseberry; a branch in flower. 831. Branch in fruit. 832. The calyx, bearing the petals and stamens, cut away from the summit of the ovary (833), and laid open. 834, 835. Sections of the unripe fruit. 836. Magnified seed, with a conspicuous raphide. 837. Longitudinal section of the same, showing the minute embryo at the extremity of the albumen.

veined leaves, usually in fascicles, often sprinkled with resinous dots. Flowers in racemes or small clusters. Calyx-tube adherent to the one-celled ovary, and more or less produced beyond it, five-lobed, sometimes colored. Petals (small) and stamens five, inserted on the calyx. Ovary with two parietal placentæ: styles more or less united. Fruit a many-seeded berry. Embryo minute, in hard albumen.—*Ex.* *Ribes* (Gooseberry and Currant). Never unwholesome: the fruit usually esculent, containing a mucilaginous and saccharine pulp, with more or less malic or citric acid. Two or three red-flowered species of Oregon and California, and the Yellow or Missouri Currant, are ornamental in cultivation.

824. *Ord. Cactaceæ (Cactus Family).* Succulent shrubby plants, peculiar in habit, with spinous buds, usually leafless: the stems either globular and many-angled, columnar with several angles, or flattened and jointed. Flowers usually large and showy. Calyx of several or numerous sepals, imbricated, coherent with and crowning the one-celled ovary, or covering its whole surface; the inner usually confounded with the indefinite petals. Stamens indefinite, with long filaments, cohering with the base of the petals.



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Styles united: stigmas and parietal placentæ several. Fruit a berry. Seeds numerous, with a curved or fleshy and rounded embryo, and little or no albumen.—All American, the greater part Mexican or on the borders of Mexico. The common *Opuntia* (Prickly Pear) extends north to New England: its mucilaginous fruit is eatable. So is the sweet red pulp of the huge *Cereus giganteus* of Sonora and South California, which forms a singular tree, forty or fifty feet high. *Cereus grandiflorus* is the magnificent Night-blooming *Cereus*.

825. *Ord. Lonsacææ.* Herbs usually clothed with rigid or stinging hairs; leaves opposite or alternate, without stipules; the flowers showy. Calyx-tube adherent to the one-celled ovary; the limb

FIG. 838. Flower of *Mamillaria cæspitosa*, of the Upper Missouri.

mostly five-parted. Petals as many, or twice as many, as the lobes of the calyx. Stamens perigynous, indefinite, and in several parcels, or sometimes definite. Style single. Ovary with three to five parietal placentæ. Seeds few or numerous, albuminous. — *Ex.* Loasa, Mentzelia, Cevallia; the latter with solitary seeds and no albumen. All American, and in the United States nearly confined to the regions beyond the Mississippi. The bristles of Loasa sting like nettles.

826. Ord. *Turneraceæ*. Herbs, with the habit of *Cistus* or *Heli-anthemum*; the alternate leaves without stipules. Flowers solitary, showy. Calyx five-lobed; the five petals and five stamens inserted on its throat. Ovary free from the calyx, one-celled, with three parietal placentæ. Styles distinct, commonly branched or many-cleft at the summit. Fruit a three-valved capsule. Seeds numerous (anatropous), with a crustaceous and reticulated testa, and a membranaceous aril on one side. Embryo in fleshy albumen. — *Ex.* *Turnera*, of which there is one species in Georgia.

827. Ord. *Passifloraceæ* (*Passion-flower Family*). Herbs, or somewhat shrubby plants, climbing by tendrils; with alternate, entire, or palmately-lobed leaves, mostly with stipules. Flowers often showy. Calyx mostly of five sepals, united below, free from the one-celled ovary; the throat bearing five petals and a filamentous crown. Stamens as many as the sepals, monadelphous, and adhering to the stalk of the ovary, which has usually three club-shaped styles or stigmas, and as many parietal placentæ. Fruit fleshy or berry-like. Seeds numerous, with a brittle sculptured testa, enclosed in pulp. Embryo enclosed in a thin albumen. — *Ex.* *Passiflora* (the *Passion-flower*, *Granadilla*): nearly all natives of tropical America. Two species are found as far north as Virginia and Ohio. Many are cultivated for their singular and showy flowers. The acidulous refrigerant pulp of *Passiflora quadrangularis* (the *Granadilla*), *P. edulis*, and others, is eaten in the West Indies, &c. But the roots are emetic, narcotic, and poisonous.

828. Ord. *Papayaceæ* comprises merely a small genus of tropical diœcious trees, of peculiar character: the principal one is the *Papaw-tree* (*Carica Papaya*) of tropical America, which has been introduced into East Florida. The fruit, when cooked, is eatable; but the juice of the unripe fruit, as well as of other parts of the plant, is a powerful vermifuge. The juice contains so much fibrine that it has an extraordinary resemblance to animal matter: meat washed

in water impregnated with this juice is rendered tender: even the exhalations from the tree are said to produce the same effect upon meat suspended among the leaves.

829. Ord. Cucurbitaceæ (*Gourd Family*). Tender or succulent herbs, climbing by tendrils; with alternate, palmately veined or lobed, rough leaves, and monœcious or diœcious flowers. Calyx of four or five (rarely six) sepals, united into a tube, and in the fertile flowers adherent to the ovary. Petals as many as the sepals, commonly more or less united into a monopetalous corolla, which coheres with the calyx. Stamens five or three, or rather two and a half, i. e. two with two-celled anthers, and one with a one-celled anther, inserted into the base of the corolla or calyx, either distinct or variously united by their filaments, and long, sinuous or contorted anthers (Fig. 465-467). Ovary one- to five-celled; the thick and fleshy placenta often filling the cells, or diverging before or after reaching the axis, and carried back so as to reach the walls of the pericarp, sometimes manifestly parietal; the dissepiments often disappearing during its growth, sometimes only one-ovuled from the top: stigmas thick, dilated or fringed. Fruit (pepo, Fig. 560) usually fleshy, with a hard rind, sometimes membranous. Seeds mostly flat, with no albumen. Embryo straight: cotyledons foliaceous. — *Ex.* The Pumpkin and Squash (*Cucurbita*), Gourd, Cucumber, and Melon. When the acrid principle which prevails throughout the order is greatly diffused, the fruits are eatable, and sometimes delicious: when concentrated, as in the Bottle Gourd, Bryony, &c., they are dangerous or actively poisonous. The officinal *Colocynth*, the resinoid and bitter pulp of the fruit of *Cucumis Colocynthis*, is very acrid and poisonous; and *Elaterium*, obtained from the juice of the Squirting Cucumber, is still more violent in its effects. The seeds of all are harmless.

830. Ord. Crassulaceæ (*Stonecrop Family*). Herbs, or slightly shrubby plants, mostly fleshy or succulent; remarkable for the complete symmetry and regularity of their flowers (449, Fig. 359-365). Calyx of three to twenty sepals, more or less united at the base, free from the ovaries, persistent. Petals as many as the sepals, rarely combined into a monopetalous corolla. Stamens as many or twice as many as the sepals, more or less perigynous. Pistils always as many as the sepals, distinct, or rarely (in *Penthorum* and *Diamorpha*) partly united: ovaries becoming follicles in fruit, several-seeded. Embryo straight, in thin albumen. — *Ex.* *Sedum* (Stone-

crop, Orpine, Live-for-ever), *Crassula*, *Sempervivum* (Houseleek), &c. They mostly grow in arid places, and are of no economical importance.

831. Ord. *Saxifragaceæ* (*Saxifrage Family*). Herbs or shrubs, with alternate or opposite leaves. Calyx of four or five more or less united sepals, either free from or more or less adherent to the ovary, persistent. Petals as many as the sepals, rarely wanting. Stamens as many, or commonly twice as many, as the pistils or sepals, or rarely indefinitely numerous, perigynous. Ovaries mostly two (sometimes three or four), usually united below and distinct above, sometimes completely united and even the styles also. Seeds numerous, with a straight embryo in fleshy albumen. The order, taken in the largest sense, includes four *tribes*, as they should probably be called, rather than suborders, which some botanists regard



even as distinct orders, viz.: The SAXIFRAGÆÆ, or true *Saxifrage Family*, which are herbs, with no manifest stipules, except the wings or appendages at the base of the petiole or radical leaves. *Ex. Sax-*

FIG. 839. *Sullivantia Ohionis*. 840. Flower with the calyx laid open, somewhat enlarged. 841. Fruit surrounded by the persistent calyx and withered petals, enlarged. 842. Section of the lower part of the capsule, magnified; showing the central placenta covered with the ascending seeds. 843. A magnified seed, with its cellular, wing-like testa. 844. Section of the nucleus, showing the embryo in the midst of albumen.

ifraga, Mitella, &c. Roots somewhat astringent, in *Heuchera* so much so that *H. Americana* is called Alum-root. **HYDRANGIÆ**: shrubs, with simple opposite leaves and no stipules. *Ex.* *Hydrangea* and *Philadelphus*, the latter polyandrous. **BAUEREÆ**: Australian shrubs, with opposite and compound sessile leaves and no stipules. **CUNONIEÆ**: woody plants, with opposite simple or compound leaves and interpetiolar stipules. **ESCALLONIEÆ**: woody plants, with alternate simple leaves and no stipules. *Ex.* *Escallonia*, of South America, *Itea*.

832. **Ord. Hamamelaceæ** (*Witch-Hazel Family*). Shrubs or small trees, with alternate simple leaves, without stipules. Flowers often polygamous. Petals valvate in æstivation. Stamens twice as many as the petals, half of them sterile; or numerous, and the petals none. Summit of the two-celled ovary free from the calyx, a single ovule suspended from the summit of each cell: styles two, distinct. Capsule cartilaginous or bony. Seeds bony, with a small embryo in hard albumen. — *Ex.* *Hamamelis* (*Witch-Hazel*), *Fothergilla*. A small order, of little importance. *Hamamelis* is remarkable for flowering late in autumn, just as its leaves are falling, and perfecting its fruit the following spring. To this order is now appended the genus *Liquidambar*, or *Sweet-Gum*, which has been taken as the type of a distinct order; but it is rather a reduced and apetalous form of the present order. It may stand as a suborder, viz.

833. **Subord. Balsamiflæ** (*Sweet-Gum Family*), consisting of a few trees, with alternate palmately-lobed leaves, and deciduous stipules; the monœcious flowers in rounded aments or heads, destitute of floral envelopes; the indurated capsules forming a head: they are two-beaked, opening between the beaks, the cells ripening one or two seeds, although the ovules are numerous. The *Sweet-gum* is so called from a fragrant balsam or *storax* which it exudes.

834. **Ord. Umbelliferæ** (*Parsley Family*). Herbs, with hollow stems, and alternate, dissected leaves, with the petioles sheathing or dilated at the base. Flowers in simple or mostly compound umbels, which are occasionally contracted into a kind of head. Calyx entirely coherent with the surface of the dicarpellary ovary; its limb reduced to a mere border, or to five small teeth. Petals five, valvate in æstivation, inserted, with the five stamens, on a disk which crowns the ovary; their points inflexed. Styles two; their bases often united and thickened, forming a stylopodium. Fruit dry, a *cremocarp*, consisting of two united carpels, at maturity sepa-

rable from each other, and often from a slender axis (*carpopphore*), into two achenia, or *mericarps*: the face by which these cohere receives the technical name of *commissure*: they are marked with a definite number of *ribs* (*juga*), which are sometimes produced into wings: the intervening spaces (*intervals*), as well as the commissure, sometimes contain canals or receptacles of volatile oil, called *vitæ*: these are the principal terms peculiarly employed in describing the plants of this difficult family. Embryo minute. Albumen hard or corneous. — *Ex.* The Carrot, Parsnip, Celery, Caraway, Anise,



Coriander, Poison Hemlock, &c. are common representatives of this well-known family. Nearly all Umbelliferous plants are furnished with a volatile oil or balsam, chiefly accumulated in the roots and in the reservoirs of the fruit, upon which their aromatic and carminative properties depend: sometimes it is small in quantity, so as merely to flavor the saccharine roots, which are used for food; as in the Carrot and Parsnip. But in many an alkaloid principle exists, pervading the foliage, stems, and roots, especially the latter, which ren-

FIG. 845. *Conium maculatum* (Poison Hemlock), a portion of the spotted stem, with a leaf; and an umbel with young fruit. 846. A flowering umbellet. 847. A flower, enlarged. 848. The fruit. 849. Cross-section of the same, showing the involute (*campylaspermous*) albumen of the two seeds. 850. Longitudinal section of one mericarp, exhibiting the minute embryo near the apex of the albumen.

ders them acrid-narcotic poisons. And, finally, many species of warm regions yield odorous gum-resins (such as Galbanum, Assa-fetida, &c.), which have active stimulant properties. The stems of Celery (*Apium graveolens*), which are acrid and poisonous when the plant grows wild in marshes, &c., are rendered innocent by



cultivation in dry ground, and by blanching. Among the virulent acrid-narcotic species, the most famous are the Hemlock (*Conium maculatum*), and *Cicuta maculata* (Cowbane, Water-Hemlock), indigenous to this country, the root of which (like that of the *C. virosa* of Europe) is a deadly poison. A drachm of the fresh root has killed a boy in less than two hours.

835. Ord. *Araliaceæ* (*Ginseng* or *Ivy Family*) scarcely differs from



the last in floral structure, except that the ovary is mostly composed of more than two carpels, and these do not separate when ripe, but

FIG. 851. Flower of *Osmorrhiza longistylis*. 852. Umbel of the same in fruit: a, the involucl. 853. The ripe mericarps separating from the axis or carpophore. 854. Cross-section of the fruit of *Angelica*, where the lateral ribs are produced into wings: the black dots represent the vittæ, as they appear in a cross-section. 855. One of the mericarps of the same, showing the inner face, or commissure, as well as the transverse section, with two of the vittæ, a.

FIG. 856. Flower of *Aralia nudicaulis* (Wild Sarsaparilla); a vertical section, displaying two of the cells of the ovary. 857. Cross-section of the ovary. 858. Longitudinal section of a seed, magnified, showing the small embryo at the upper end.

become drupes or berries; and the albumen is not hard like horn, but only fleshy. — *Ex.* *Aralia* (the Spikenard, the Wild Sarsaparilla, Ginseng), and *Hedera* (the Ivy). Their properties are aromatic, stimulant, somewhat tonic, and alterative.

836. *Ord. Cornaceæ* (*Cornel* or *Dogwood Family*). Chiefly trees or shrubs; with the leaves almost always opposite, destitute of stipules. Flowers in cymes, sometimes in heads surrounded by colored involucre. Calyx coherent with the two-celled ovary; the very small limb four-toothed. Petals four, valvate in æstivation. Stamens four, alternate with the petals. Styles united into one. Fruit a two-celled drupe. Embryo nearly as long as the albumen; cotyledons broad and flat. — *Ex.* *Cornus*, the Dogwood. Chiefly remarkable for their bitter and astringent bark, which in this country has been substituted for Cinchona. The peculiar principle they contain is named *Cornine*. *Cornus Canadensis* (Fig. 321, 322) is a low and herbaceous species. — A reduced form of this order occurs in *Nyssa* (the Tupelo or Sour-Gum), which has dicecious or polygamous flowers, the sterile ones at least apetalous, the fertile ones appearing to be so on account of the limb of the adherent calyx being obsolete; the style stigmatic down one side and revolute; the ovary and drupe one-celled and one-seeded. The fruit is acid. The wood of the common Sour or Black Gum-tree, or Peperidge, is close-grained, and hard to split.

Division II. MONOPETALOUS EXOGENOUS PLANTS.

Floral envelopes consisting of both calyx and corolla: the petals more or less united (corolla gamopetalous). — A few true *Ericaceæ*, with all the *Pyroleæ* and some *Monotropeæ*, are polypetalous: the *Aquifoliaceæ* are nearly so, as are some of several of the succeeding orders, and *Fraxinus*, &c. in *Oleaceæ*. The latter genus is apetalous, and so are one or two genera in other generally Monopetalous orders.

CONSPECTUS OF THE ORDERS.

Group 1. Ovary coherent with the calyx, two- to several-celled, with one or many ovules in each cell. Seeds albuminous, with a small embryo. Stamens inserted on the corolla. Leaves opposite.

Stipules wanting.

CAPRIFOLIACEÆ.

Stipules interpetiolar (or in one group the leaves whorled).

RUBIACEÆ.

Group 2. Ovary coherent with the calyx, one-celled and one-ovuled, or rarely 3-celled with two of the cells empty, and the third one-ovuled. Seed with little or no albumen. Stamens inserted on the corolla. Limb of the calyx a mere ring, crown, or pappus, or none. Stipules none.

Stamens distinct. Seed suspended. Leaves opposite. Stamens 3, or rarely 2.

Flowers often irregular.

VALERIANACEÆ.

Stamens 4. Flowers regular, in an involucrate head.

DIPSACEÆ.

Stamens syngenesious. Seed erect.

COMPOSITÆ.

Group 3. Ovary coherent with the calyx, with two or more cells and numerous ovules. Seeds albuminous. Stamens inserted with the corolla (epigynous) : anthers not opening by pores. Juice more or less milky.

Corolla irregular. Stamens united by their anthers or filaments. LOBELIACEÆ.

Corolla regular. Stamens distinct.

CAMPANULACEÆ.

Group 4. Ovary free from the calyx, or sometimes coherent with it, with two or more cells and few or many ovules. Seeds albuminous. Stamens inserted with the corolla, or rarely somewhat coherent with its base, as many, or twice as many, as its lobes : anthers mostly opening by pores or chinks.

ERICACEÆ.

Group 5. Ovary free, or rarely coherent with the calyx, several-celled, with a single ovule (or at least a single seed) in each cell. Seeds mostly albuminous. Stamens definite, as many as the lobes of the (often almost polypetalous) corolla and alternate with them, or two to four times as many : anthers not opening by pores. — Trees or shrubs.

Stamens as many as the lobes of the corolla : no sterile ones. AQUIFOLIACEÆ.

Stamens more numerous than the lobes of the corolla, and all fertile.

Flowers polygamous : calyx free.

EBENACEÆ.

Flowers perfect : calyx more or less adnate.

STYRACACEÆ.

Stamens as many fertile as the lobes of the corolla and opposite them.

SAPOTACEÆ.

Group 6. Ovary free, or with the base merely coherent with the tube of the calyx, one-celled, with a free central placenta. Stamens inserted into the regular corolla opposite its lobes ! which they equal in number. Seeds albuminous.

Shrubs or trees (all tropical) : fruit drupaceous.

MYRSINACEÆ.

Herbs : fruit capsular.

PRIMULACEÆ.

Group 7. Ovary free, one-celled, with a single ovule ; or two-celled with several ovules attached to a thick central placenta. Stamens as many as the lobes of the regular corolla or the nearly distinct petals. Seeds albuminous.

Ovary two-celled : style single : stamens 4, or rarely less.

PLANTAGINACEÆ.

Ovary one-celled : styles and stamens 5.

PLUMBAGINACEÆ.

Group 8. Ovary free, or rarely partly coherent, one- or two- (or spuriously

four-) celled, with numerous ovules. Corolla bilabiate or irregular; the stamens inserted upon its tube, and mostly fewer than its lobes.

Ovary 1-celled with a central placenta. Stamens 2. LENTIBULACEÆ.

Ovary 1-celled, or spuriously 2-5-celled with parietal placenta.

Seeds very numerous and minute, albuminous.

Plants destitute of green herbage.

OROBANCHACEÆ.

Plants with green herbage.

GESNERIACEÆ.

Seeds few or many, large: albumen none.

BIGNONIACEÆ.

Ovary 2-celled, with the placenta in the axis.

Corolla convolute in aestivation. Seeds few; no albumen. ACANTHACEÆ.

Corolla imbricated in aestivation. Seeds albuminous. SCROPHULARIACEÆ.

Group 9. Ovary free, two- to four-lobed, or at least separating or splitting into as many one-seeded nuts or achenia, or drupaceous. Corolla regular or irregular; the stamens inserted on its tube, equal in number or fewer than its lobes. Albumen little or none.

Stamens 4, didynamous, or 2. Corolla more or less irregular.

Ovary not 4-lobed: style terminal.

VERBENACEÆ.

Ovary of 4 lobes around the base of the style.

LABIATE.

Stamens 5. Flower regular. Leaves alternate.

BOERAGINACEÆ.

Group 10. Ovary free, compound, or rarely the carpels two or more and distinct: the ovules usually several or numerous. Corolla regular; the stamens inserted upon its tube, as many as the lobes and alternate with them. Seeds albuminous.

Placenta 2, parietal (sometimes expanded or united). Embryo minute.

Hairy herbs. Albumen cartilaginous.

HYDROPHYLLACEÆ.

Smooth herbs. Albumen fleshy.

GENTIANACEÆ.

Placenta in the axis: ovary with 2, 3, or rarely several cells.

Embryo large, coiled or folded. Seeds few.

CONVOLVULACEÆ.

Embryo straight, with broad cotyledons.

POLEMONIACEÆ.

Embryo curved, rarely straight, slender. Seeds numerous.

SOLANACEÆ.

Group 11. Ovaries 2 and distinct (or sometimes united), but the stigmas united into one and often the styles also. Stamens as many as and alternate with the lobes of the regular corolla, which is convolute, or rarely valvate in aestivation. Anthers often connected with the stigma. Fruit usually a pair of follicles. Seeds mostly numerous, often comose. Embryo large and straight, in sparing albumen. Juice milky.

Pollen powdery.

APOCYNACEÆ.

Pollen in waxy or granular masses.

ASCLEPIADACEÆ.

Group 12. Ovary free, two-celled, the cells mostly two-ovuled, and the fruit one-seeded. Corolla regular (sometimes nearly polypetalous or wanting); the stamens (two) fewer than its lobes.—Shrubs or trees.

Seeds erect. Corolla imbricated or contorted in aestivation.

JASMINACEÆ.

Seeds suspended. Corolla valvate in aestivation.

OLEACEÆ.

837. Ord. *Caprifoliaceæ* (*Honeysuckle Family*). Mostly shrubs, often twining, with opposite leaves, and no stipules (but *Viburnum* often has appendages like them). Calyx-tube adnate to the 2-5-celled ovary; the limb 4-5-cleft. Corolla regular or irregular. Stamens inserted on the corolla, as many as the petals of which it is composed, and alternate with them, or rarely one fewer. Fruit mostly a berry or drupe. Seeds pendulous, albuminous. — *Ex.* The Honeysuckles (*Lonicera*), which have usually a peculiar bilabiate corolla (473), the Snowberry (*Symphoricarpos*), *Diervilla*, which has a capsular fruit, &c., compose the tribe *LONICERÆ*, characterized by their tubular flowers and filiform style: while the Elder (*Sambucus*) and *Viburnum*, which have a rotate or urn-shaped corolla, form the tribe *SAMBUCEÆ*. Chiefly plants of temperate



regions. Several species, such as Honeysuckle, &c., are widely cultivated for ornament. They are generally bitter, and rather active or nauseous in their properties.

838. Ord. *Rubiaceæ* (*Madder Family*). Shrubs or trees, or often herbs, with the entire leaves either in whorls, or opposite and furnished with stipules. Calyx-tube completely, or rarely incompletely

FIG. 859. Branch of *Lonicera* (*Xylosteon*) *oblongifolia*: the two ovaries united! 860. *Lonicera* (*Caprifolium*) *parviflora*. 861. A flower about the natural size. 862. Longitudinal section of the ovary. 863. Longitudinal section of a magnified seed, showing the albumen and minute embryo.

adnate to the 2-5-celled ovary; the limb four- or five-cleft or toothed, or occasionally obsolete. Stamens as many as the lobes of the regular corolla, and alternate with them, inserted on the tube. Fruit various. Seeds albuminous.—This extensive family divides into two principal suborders, viz.:—

839. Subord. *Stellatæ* (*Madder Family proper*). • Herbs, with the leaves in whorls; but all except a single pair are generally supposed to take the place of stipules.—*Ex.* Galium, Rubia (the Madder), &c., nearly all belonging to the colder parts of the world. The roots of Madder yield the important dye of that name; and those of several species of Galium are imbued with a similar red coloring-matter.

840. Subord. *Cinchonæ* (*Peruvian-Bark Family*). Shrubs, trees, or herbs; the leaves opposite and furnished with stipules, which are very various in form and appearance.—*Ex.* Cephalanthus (Button-



brush), Pinkneya, and an immense number of tropical genera. Very active, and generally febrifugal properties prevail in this large order. It furnishes some of the most valuable known remedial agents, among them *Peruvian Bark* or *Cinchona*, and *Ipecacuanha*.

FIG. 864. Piece of *Rubia tinctoria* (the Madder) in flower. 865. The fruit. 866 The two constituent portions of the fruit separating. 867. Vertical section of one carpel, showing the curved embryo. 868. Section of a flower of *Galium*.

FIG. 869. *Cephalanthus occidentalis*, the Button-Bush. 870. A flower, taken from the head. 871. The corolla laid open.

The febrifugal properties of the former depend on the presence of two alkaloids, *Cinchonia* and *Quinia*, both combined with *Kinic acid*. The *Quinquina barks*, which are derived from some species of *Exostemma* and other West Indian, Mexican, and Brazilian genera, contain neither cinchonina nor quinia. The bark of *Pinckneya pubens*, of the Southern United States, has been substituted for *Cinchona*. — The true *Ipecacuanha* is furnished by the roots of *Cephaelis Ipecacuanha* of Brazil and New Granada. Its emetic principle (called *Emetine*) also exists in *Psychotria emetica* of New Granada, which furnishes the *striated, black*, or *Peruvian Ipecacuanha*. The order likewise furnishes *Coffee*, the horny seed (albumen) of *Coffea Arabica*. According to Blume, the leaves of the Coffee-plant are used as a substitute for tea in Java. — To this order may be appended, either as a suborder, or, as in a general work it is more conveniently regarded, the



841. Ord. *Loganiaceæ*, which may be briefly said to be *Rubiaceæ* with a free calyx, and manifestly connected with the *Cinchonææ* through the *Houstonia* section of *Oldenlandia*, with a partly free

FIG. 872. *Oldenlandia (Houstonia) crerulea*. 873, 874. The two sorts of flowers that different individuals bear, with the corolla laid open; one with the stamens at the base, the other at the summit of the tube: the lower figure shows also a section of the ovary. 875. Cross-section of an anther, magnified. 876. Anther less enlarged, opening longitudinally. 877. Capsule with the calyx. 878, 879. Views of the capsule in dehiscence. 880. Diagram of a cross-section of the unexpanded flower.

calyx. On the other hand, they run close to Scrophulariaceæ and Apocynaceæ.—*Spigelia Marilandica* (the Carolina Pink-root, a well known vermifuge, of somewhat acrid-narcotic properties), and *Gelsemium* (the so-called Yellow Jessamine of the Southern States) are the most conspicuous representatives of the group in this country. The active properties of the family are most conspicuous in species of *Strychnos*. The fatal drug, *Nux-vomica*, from which *strychnine* is extracted, consists of the seeds of an East Indian *Strychnos*. *Tiute*, another frightful poison, is prepared from a Java species, and the Ouari poison of South America, from a third species. Meanwhile a Brazilian species, *S. Pseudoquina*, has a harmless fruit, and its bark (*Copalche bark*) is reputed to be an excellent febrifuge, fully equal to *Cinchona*.

842. Ord. *Valerianaceæ* (*Valerian Family*). Herbs with opposite leaves, and no stipules. Flowers often in cymes, panicles, or heads. Limb of the adnate calyx two- to four-toothed, obsolete, or else



forming a kind of pappus. Corolla tubular or funnel-form, sometimes with a spur at the base, four- or five-lobed. Stamens distinct, inserted on the corolla, usually fewer than its lobes. Ovary one-

FIG. 881. Branch of *Fedla Fagopyrum*. 882. A magnified flower. 883. A fruit. 884. An enlarged cross-section of the same, and the cotyledons of the seed in the single fertile cell: the two empty cells are confluent into one. 885. Flower of a *Valerian*, with one of the pappus-like bristles of the calyx unrolled. 886. Section through the ovary and embryo; the bristles of the calyx broken away.

ovuled, with one perfect cell and two abortive ones. Fruit a kind of achenium. Seed suspended, exalbuminous. Embryo straight. radicle superior. — *Ex.* Valeriana, the Valerian, and Fedia, the Lamb-Lettuce: the latter is eaten as a salad. The perennial species, especially the roots, exhale a heavy and peculiar odor, have a somewhat bitter, acrid taste, and are antispasmodic and vermifugal. *Valerian* of the shops is chiefly from *Valeriana officinalis* of the South of Europe. It produces a peculiar intoxication in cats. The large roots of *V. edulis* are eaten by the aborigines of Oregon. The famous *Spikenard* of the ancients, esteemed as a stimulant medicine as well as a perfume, is the root of a *Nardostachys* of the Himalayas.

843. Ord. *Dipsacæ* (*Teasel Family*). Herbs, with opposite or whorled sessile leaves, destitute of stipules. Flowers in dense heads, which are surrounded by an involucre. Limb of the adnate calyx cup-shaped and entire or toothed, or forming a bristly or plumose pappus. Corolla tubular; the limb four- or five-lobed, somewhat irregular. Stamens four, distinct, or rarely united in pairs, often unequal, inserted on the corolla. Ovary one-celled, one-ovuled. Seed suspended, albuminous. — *Ex.* *Dipsacus*, the Teasel, and *Scabiosa*, or Scabious. All natives of the Old World. *Teasels* are the dried heads of *Dipsacus fullonum*, covered with stiff and spiny bracts, with recurved points.

844. Ord. *Compositæ* (*Composite or Sunflower Family*). Herbs or shrubs; with the flowers in heads (compound flowers of the



older botanists, 394, Fig. 323 – 325), crowded on a receptacle, and surrounded by a set of bracts (*scales*) forming an involucre; the separate flowers often furnished with bractlets (*chaff, paleæ*). Limb of the adnate calyx obsolete, or a *pappus* (Fig. 569 – 573), consisting

FIG. 887. A head of flowers of Cichory (Fig. 323) vertically divided.

of hairs, bristles, scales, &c. Corolla regular or irregular. Stamens five, as many as the lobes or teeth of the regular corolla, inserted on its tube: anthers united into a tube (*syngenesious*, Fig. 463, 464). Style two-cleft. Ovule solitary, erect, anatropous. Fruit an achenium (Fig. 568-573), either naked or crowned with a pappus. Seed destitute of albumen. Embryo straight. — This vast but very natural family is divided into three series or suborders; viz.:—

845. *Subord. Tubulifloræ*. Corolla tubular and regularly four- or five-lobed, either in all the flowers (when the head is *discoid*), or in the central ones (those of the *disk*) only, the marginal or *ray flowers* presenting a *ligulate* or strap-shaped corolla. — *Ex.* *Liatris*, *Eupatorium*, &c.; where the heads are *homogamous*, that is, the flowers all tubular, similar and perfect: *Helianthus* (Sunflower), *Helenium*, *Aster*, &c.; where the heads are *heterogamous*; the *disk flowers* being tubular and perfect, while those of the *ray* are *ligulate*, and either pistillate only, or *neutral*, that is, destitute of both stamens and pistils.

846. *Subord. Labiatifloræ*. Corolla of the disk-flowers bilabiate. — *Ex.* *Chaptalia*, of the Southern United States; and many South American genera, &c.

847. *Subord. Ligulifloræ*. Corolla of the flowers (both of the disk and ray) all ligulate and perfect. — *Ex.* The Dandelion, Lettuce, Cichory (Fig. 887), &c.

848. This vast family comprises about a tenth part of all *Phænogamous* plants. A bitter and astringent principle pervades the whole order; which in some is tonic (as in the Chamomile, the Boneset or Thoroughwort, &c.); in others, combined with mucilage, so that they are demulcent as well as tonic (*Elecampane* and *Colts-foot*); in many, aromatic and extremely bitter (such as *Wormwood* and all the species of *Artemisia*); sometimes accompanied by acrid qualities, as in the Tansy and the Mayweed, the bruised fresh herbage of which blisters the skin. The species of *Liatris*, which abound in terebinthine juice, are among the reputed remedies for the bites of serpents; so are some species of *Mikania* in Central America. The juice of *Silphium* and of some Sunflowers is resinous. The leaves of *Solidago odora*, which owe their pleasant anisate fragrance to a peculiar volatile oil, are infused as a substitute for tea. From the seeds of Sunflower, and several other plants of the order, a bland oil is expressed. The tubers of *Helianthus tuberosus* are eaten

under the name of *Jerusalem artichokes*; *Girasola*, the Italian name of Sunflower, having become Anglicized into *Jerusalem*. True *artichokes* are the fleshy receptacle and imbricated scales of *Cynara Scolymus*. The flowers of *Carthamus tinctorius*, often called Saffron, yield a yellow dye, much inferior in quality to true Saffron. — The *Ligulifloræ*, or *Cichoraceæ*, all have a milky juice, which is narcotic, and has been employed as a substitute for *opium*. The bland young leaves of the garden Lettuce are a common salad. The



roasted roots of the Wild Succory (*Cichorium Intybus*) are ex-

FIG. 888. Head of *Liatris squarrosa* (discoid; the flowers all tubular and perfect). 889. The same, with the scales of one side of the imbricated involucre removed; and also all the flowers but one, showing the naked flat receptacle. 890. Portion of one of the plumose bristles of the capillary pappus. 891. Head of *Helenium autumnale* (heterogamous); the rays neutral, consisting merely of a ligulate corolla. 892. The same, with the flowers all removed from the roundish receptacle, except a single disk-flower and one or two rays: the reflexed scales of the involucre in a single series. 893. Magnified disk-flower of the same: the corolla exhibiting the peculiar venation of the family; namely, the veins corresponding to the sinuses, and sending a branch along the margins of the lobes. 894. The same, with the corolla removed; the achenium crowned with the limb of the calyx in the form of a chaffy pappus, of about five scales. 895. A chaff of the pappus more magnified. 896. A tubular corolla of this family laid open, showing the venation; and also the five syngenesious anthers united in a tube, through which the two-cleft style passes. 897. Head of *Dracopis amplexicaulis*, with the flowers removed from the elongated spike-like receptacle, except a few at the base: a, achenium of one of the disk-flowers magnified, partly enclosed by its bractlet (chaff or palea); the pappus obsolete. 898. Part of the involucre and alveolate (honeycomb-like) receptacle of *Onopordon* or Cotton-Thistle. 899. A perfect and ligulate flower of the Dandelion, with its hair-like or capillary pappus.

tensively used to adulterate coffee: and the roots of some species of *Tragopogon* (Salsify, Oyster-plant) and *Scorzonera* are well-known esculents.

849. **Ord. Lobeliaceæ** (*Lobelia Family*). Herbs or somewhat shrubby plants, often yielding a milky juice, with alternate leaves and perfect flowers. Limb of the adnate calyx five-cleft. Corolla irregularly five-lobed, usually appearing bilabiate, cleft on one side nearly or quite to the base. Stamens 5, epigynous, coherent into a tube. Stigma fringed. Capsule one-several-celled, many-seeded. Seeds albuminous.—*Ex. Lobelia*. All narcotico-acrid poisons. The well-known *Lobelia inflata* (Indian Tobacco) is one of the most powerful articles of the materia medica, and most dangerous in the hands of the reckless quacks who use it.—This order is only a form of the next, with irregular flowers.

850. **Ord. Campanulaceæ** (*Campanula Family*). Herbs, like the last, but the juice less acrid, and the corolla regular, campanulate,



usually five-lobed, withering. Stamens five, distinct. Style fur-

FIG. 900. *Campanula rotundifolia*, much reduced in size. 901. *Lobelia inflata*, reduced in size. 902. A flower, enlarged. 903. The united filaments and anthers enclosing the style; the corolla and limb of the calyx cut away. 904. The stigma surrounded by a fringe. 905. Transverse section of a capsule. 906. Section of a magnified seed, showing the embryo.

nished with collecting hairs.—*Ex.* Campanula (Bell-flower, Harebell). Plants of little known importance to man, except for ornament.

851. *Ord. Ericaceæ (Heath Family)*. Shrubs, or small trees, rarely herbs. Flowers regular and symmetrical, or nearly so; the petals sometimes distinct. Stamens mostly distinct, free from the corolla, as many or twice as many as its lobes, and inserted with it (either hypogynous or epigynous): anthers often appendaged, commonly opening by terminal pores. Pollen compound (of four united grains) except in the last suborder. Styles and stigmas united into one. Ovary with two or more cells and usually numerous ovules, free, or in *Vaccinææ* coherent with the calyx-tube. Seeds usually indefinite, albuminous.—Most botanists give the rank of orders to the following suborders.



852. *Subord. Vaccinææ (Whortleberry Family)*. Ovary adnate to the tube of the calyx, becoming a berry or drupaceous. Anthers two-celled; the cells nearly distinct, mostly prolonged above into a tube. Shrubs, with scattered or alternate leaves, often evergreen.—*Ex.* Vaccinium (Bilberry, Blueberry, Cranberry) and Gaylussacia (Whortleberry or Huckleberry).

853. *Subord. Ericinææ (True Heath Family)*. Ovary free from the calyx. Fruit capsular, sometimes baccate or drupaceous. Mostly shrubs. Leaves various, often evergreen. Petals rarely distinct.—*Ex.* Erica (Heath), Kalmia, Rhododendron, Gaultheria, Andromeda, &c.

FIG. 907. Branch of *Rhododendron Lapponicum*. 908. Enlarged flower, with its pedicel and bracts. 909. A flower with the corolla removed, more enlarged. 910. The capsule of *R. maximum*, opening by septical dehiscence; the valves breaking away from the persistent axis, or columella.

854. Subord. Epacridæ (*Epacris* Family). Shrubby plants of the Southern hemisphere, with the aspect and character of Heaths, but the anthers one-celled are not appendaged.

855. Subord. Pyroleæ (*Pyrola* Family). Ovary free from the calyx. Petals distinct. Anthers two-celled. Fruit a capsule. Seeds with a very loose cellular testa. Mostly herbs. Leaves flat and broad, evergreen. — *Ex.* *Pyrola*, *Chimaphila*.



856. Subord. Monotropæ (*Indian-Pipe* Family). Ovary free from the calyx. Petals distinct or united. Anthers two-celled, or confluent one-celled. Pollen simple. Fruit a capsule. Seeds with a loose or winged testa. Parasitic herbs, destitute of green color,

FIG. 911. *Gaultheria procumbens* (Checkerberry, &c.) 912. The enlarging calyx in the immature fruit. 913. Vertical section of the pulpy or berry-like calyx and the included capsule (the seeds removed from the placenta in one cell). 914. Horizontal section of the same, showing the five-celled capsule, with a placenta proceeding from the inner angle of each cell. 915. Section of a seed, magnified. 916. Flower of a *Vaccinium* (Blueberry). 917. Vertical section of the ovary and adherent calyx. 918. Anther of *Vaccinium Vitis-Idæa*; each cell prolonged into a tube, and opening by a terminal pore. 919. Anther of *Vaccinium Myrtillus*; the connectivum furnished with two appendages. 920. Stamen of an *Andromeda* (*Cassiope*), showing the appendages of the connectivum. 921. Stamen of *Arctostaphylos Uva-Ursi*, showing the separate anther-cells, opening by a terminal pore, the appendages of the connectivum, and the filament, which is swollen at the base.

and with scales instead of leaves.—*Ex.* *Monotropa*, the Indian-Pipe and Pinesap.

857. In this diversified and widely diffused order, the bark and foliage are generally astringent, often stimulant or aromatic from a volatile oil or a resinous matter, and not seldom narcotic. Thus, the leaves of *Rhododendron*, *Kalmia*, and all the related plants, are deleterious (being stimulant narcotics), or suspicious. The honey made from their flowers is sometimes poisonous. The *Uva-Ursi* and the *Chimaphila* (*Pipsissewa*) are the chief medicinal plants of



the order. The berries are generally edible, and some are largely used for the dessert; as Cranberries, Blueberries, and Huckleberries. The fleshy calyx of *Gaultheria* (Checkerberry, or Wintergreen) has a very pleasant and well-known aroma. Many *Ericaceæ* are cultivated for ornament, especially *Rhododendrons* and *Azaleas*, *Heaths* and *Epacrises*.

FIG. 922. *Pyrola chlorantha*, reduced in size. 923. Enlarged flower. 924. Magnified stamen. 925. Pistil. 926. Cross-section of the capsule. 927. A highly magnified seed. 928. The nucleus removed from the loose cellular testa, and divided, showing the very minute embryo.

FIG. 929. *Monotropa uniflora*. 930. A petal. 931. Capsule, with the stamens. 932. Transverse section of the same; the thick and lobed placenta covered with very minute seeds.

858. Ord. Aquifoliaceæ (*Holly Family*). Trees or shrubs, commonly with coriaceous leaves, and small axillary polygamous flowers. Calyx of four to six sepals. Corolla four- to six-parted or cleft: the stamens as many as its segments and alternate with them, inserted on the base of the corolla. Anthers opening longitudinally. Ovary two- to six-celled; the cells with a single suspended ovule. Fruit drupaceous, with two to six nutlets. Embryo minute, in hard albumen. — *Ex.* Ilex, the Holly, &c. The bark and leaves contain a tonic, bitter, extractive matter. The leaves of a species of Ilex are used for tea in Paraguay: and the famous *black drink* of the Creek Indians is prepared from the leaves of Ilex vomitoria (Cassena); which are still used as a substitute for tea in some parts of the Southern States.

859. Ord. Ebenaceæ (*Ebony Family*). Trees or shrubs, destitute of milky juice, with alternate, mostly entire leaves, and polygamous flowers. Calyx three- to six-cleft, free from the ovary. Corolla three- to six-cleft, often pubescent. Stamens twice to four times as many as the lobes of the corolla, inserted on them. Ovary three- to several-celled; the style with as many divisions. Fruit a kind of berry, with large and bony seeds. Embryo shorter than the hard



albumen. — *Ex.* Diospyros, the Persimmon. The fruit, which is extremely austere and astringent when green, becomes sweet and eatable when fully ripe. The bark is powerfully astringent. *Ebony* is the wood of Diospyros Ebenus and other African and Asiatic species.

860. Ord. Styracaceæ (*Storax Family*). Shrubs or trees, with per-

FIG. 933. Perfect flower of Diospyros Virginiana, the Persimmon. 934. The corolla, laid open, and stamens. 935. The fruit. 936. Section through the fruit and bony seeds. 937. Vertical section of a seed. 938. The detached embryo.

fect flowers. Calyx-tube generally coherent either with the base of the ovary, or with its whole surface. Petals often distinct or nearly so. Styles and stigmas perfectly united into one. Stamens definite, or in the suborder SYMPLOCINEÆ mostly indefinite; filaments more or less united. Cells of the ovary opposite the calyx-lobes. Otherwise much as in the last family. — *Ex.* *Styrax*, *Halesia*, *Symplocos*. Some yield a fragrant, balsamic resinous substance; such as *Storax* and *Benzoin*, containing *Benzoic acid*. The sweet leaves of our *Symplocos tinctoria* afford a yellow dye.

861. Ord. *Sapotaceæ* (*Sapodilla Family*). Trees or shrubs, usually with a milky juice; the leaves alternate, entire, coriaceous, the upper surface commonly shining. Flowers perfect, regular, axillary, usually in clusters. Corolla four- to eight- (or many-) cleft. Stamens distinct, inserted on the tube of the corolla, commonly twice as many as its lobes, half of them fertile and opposite the lobes, the others petaloid scales or filaments and alternate with them: anthers extrorse. Ovary 4–12-celled, with a single ovule in each cell. Styles united into one. Fruit a berry. Seeds with a bony testa, with or without albumen. — *Ex.* *Bumelia*, of the Southern United States. The fruit of many species is sweet and eatable; such as the *Sapodilla Plum*, the *Marmalade*, the *Star-Apple*, and other West Indian species. The large seeds, particularly of some kinds of *Bassia*, yield a bland fixed oil, which is sometimes thick and like butter, as in the *Chee* of India (*B. butyracea*), and the African *Butter-tree*.

862. Ord. *Myrsinaceæ*. Trees or shrubs, mostly with alternate coriaceous leaves, which are often dotted with glands, and with all the characters of *Primulaceæ*, except the drupaceous fruit and arborescent habit. — Nearly all tropical (*Ardisia*, *Myrsine*).

863. Ord. *Primulaceæ* (*Primrose Family*). Herbs, with opposite, whorled, or alternate leaves, often with naked scapes and the leaves crowded at the base. Flowers regular. Stamens inserted on the tube of the corolla, as many as its lobes and opposite them! Ovary free, with one partial exception, one-celled with a free central placenta! Ovules mostly indefinite and amphitropous. Style and stigma single. Fruit capsular: the fleshy central placenta attached to the base of the cell. Seeds albuminous. Embryo transverse. — *Ex.* *Primula* (*Primrose*), *Cyclamen*, *Anagallis*. In *Samolus*, the calyx coheres with the base of the ovary, and there is a row of sterile filaments occupying the normal position of the first set of

stamens, namely, alternate with the lobes of the corolla. Several are ornamental in cultivation, such as Primroses and Auriculas.



864. Ord. Plantaginaceæ (*Plantain Family*). Chiefly low herbs, with small spiked flowers on scapes, and ribbed radical leaves. — Calyx four-cleft, persistent. Corolla tubular or urn-shaped, scarious and persistent; the limb four-cleft. Stamens four, rarely two, inserted on the tube of the corolla alternate with its segments; the persistent filaments long and flaccid. Ovary two-celled: style single. Capsule membranaceous, circumscissile; the cells one- to several-seeded. Embryo large, straight, in fleshy albumen. — *Ex.* *Plantago*, the Plantain, or Ribgrass, is the principal genus of the order. Of no important economical qualities.

865. Ord. Plumbaginaceæ (*Leadwort Family*). Perennial herbs,

FIG. 939. *Primula Mistassinica*. 940. The corolla removed; its tube laid open. 941. The calyx divided vertically, showing the pistil. 942. Vertical section of the ovary and of the free central placenta, covered with ovules, which nearly fills the cell. 943. Capsule of *Primula veris*, dehiscence at the summit by numerous teeth. 944. A magnified seed. 945. Section of the same, exhibiting the transverse embryo.

FIG. 946. Branch of *Anagallis arvensis* (Pimpernel), with a capsule showing the line of circumscissile dehiscence. 947. The capsule (pyxis), with the lid falling away.

or somewhat shrubby plants; with the flowers often on simple or branching scapes, and the leaves crowded at the base, entire, mostly sheathing or clasping. — Calyx tubular, plaited, five-toothed, persistent. Corolla salver-shaped, with a five-parted limb, the five stamens inserted on the receptacle opposite its lobes (*Plumbago*); or else of five almost distinct unguiculate (scarious or coriaceous) petals, with the stamens inserted on their claws! (*Statice*, &c.) In the former



case the five styles are united nearly to the top; but in the latter they are separate! Ovary one-celled, with a single ovule pendulous from a strap-shaped funiculus which rises from the base of the cell. Fruit a utricle, or opening by five valves. Embryo large, in thin albumen. — *Ex.* *Statice* (Marsh-Rosemary or Sea-Lavender) and *Armeria* (Thrift); sea-side or saline plants. They have astringent roots; none more so than those of our own Marsh-Rosemary or Sea-Lavender, one of the purest astringents of the materia medica.

866. *Ord. Lentibulaceæ (Bladderwort Family)*. Small herbs, growing in water, or wet places, with the flowers on scapes; the leaves either submersed and dissected into filiform segments resembling rootlets, and commonly furnished with air-bladders to render them

FIG. 948. A flower of *Plantago major*, enlarged. 949. Pistil. 950. Capsule (pyxis), with the marcescent corolla. 951. Cross-section of a pod and seeds. 952. Vertical section of a seed.

FIG. 953. Corolla, and 954, calyx of Thrift (*Armeria vulgaris*). 955. Pistil with distinct styles. 956. Cross-section of the pod and seed. 957. Vertical section of the ovary, magnified, to show the ovule.

buoyant, sometimes evanescent or wanting, or when produced in the air entire and somewhat fleshy, clustered at the base of the scape. Flowers showy, very irregular. Calyx of two sepals, or unequally five-parted. Corolla bilabiate, personate; the very short tube spurred. Stamens two, inserted on the upper lip of the corolla: anthers confluent one-celled. Ovary free, one-celled with a free central placenta! bearing numerous ovules. Seeds destitute of albumen. Embryo straight. — *Ex.* Utricularia (Bladderwort), Pinguicula. Unimportant plants,

867. Ord. *Orobanchaceæ* (*Broom-Rape Family*). Herbs, destitute of green foliage, and with scales in place of leaves, parasitic on the roots of other plants. Corolla withering or persistent, with a bilabiate or more or less irregular limb. Stamens four, didynamous,



inserted on the corolla. Ovary free, one-celled, with two parietal placentæ! which are often two-lobed, or divided. Capsule enclosed

FIG. 958. Branch of *Epiphegus Virginiana* (Beech-drops), nearly of the natural size: the lower flowers, with short imperfect corollas, alone producing ripe seeds. 959. A flower enlarged. 960. Longitudinal section of the same. 961. Longitudinal section of the ovary, more magnified, showing one of the parietal placentæ covered with minute ovules. 962. Cross-section of the same, showing the two parietal placentæ. 963. A highly magnified seed. 964. Section of the same, exhibiting the minute embryo next the hilum.

FIG. 965. *Aphyllon uniflorum*. 966. A flower about the size of nature. 967. The same laid open, showing the didynamous stamens and the pistil. 968. A magnified anther. 969. A magnified seed. 970. Section of the same.

in the persistent corolla. Seeds very numerous, minute. Embryo minute at the extremity of the albumen.—*Ex.* Orobanche, Epiphegus (Beech-drops), &c. Astringent, bitter, and escharotic. The pulverized root of Epiphegus (thence called Cancer-root) is applied to open cancers.

868. *Ord. Gesneriaceæ*, consisting chiefly of tropical herbs or tender shrubby plants, with green foliage and showy flowers, the calyx often partly adherent to the ovary, agrees with Orobanchaceæ in the parietal placentation, structure of the seeds, &c. Many are cultivated in conservatories for ornament, such as species of *Gloxinia* and *Achimenes*.

869. *Ord. Bignoniaceæ (Bignonia Family)*. Mostly trees, or climbing or twining shrubby plants, with large and showy flowers, and opposite, simple, or mostly pinnately-compound leaves. Corolla with a more or less irregular five-lobed or bilabiate limb. Stamens five, of which one, and often three, are reduced to sterile filaments or rudiments (Fig. 409), or four and didynamous. Ovary one-celled with two parietal placentæ, or two-celled by a false partition stretched between the placentæ, or rarely by their meeting in the axis. Pod two-valved, many-seeded. Seeds winged (Fig. 601), destitute of albumen. Cotyledons foliaceous, flat, heart-shaped, also notched at the apex.—*Ex.* *Bignonia*, *Tecoma* (Trumpet-creeper), *Catalpa*, and other tropical genera. Of little importance, except as ornamental plants.

870. *Subord. Sesameæ (Sesamum Family)* has few and wingless seeds; the fruit generally indurated or drupaceous, often two- to four-horned, sometimes perforated in the centre from the dissepiments not reaching the axis before they diverge and become placentiferous, and spuriously four- to eight-celled by the cohesion of parts of the placentæ with the walls of the pericarp.—*Ex.* *Sesamum*, *Martynia* (Unicorn-plant), and a few tropical plants. They are mucilaginous; and the seeds of *Sesamum* yield a good fixed oil.

871. *Subord. Crescentiæ*, consists of the Calabash-tree (*Crescentia Cujete*) and a few allies, among them *Parmentiera edulis*, the Candle-tree of Panama, which also have wingless seeds. The subacid pulp of the gourd-like fruit is edible; the hard shell is used for bottles, or *calabashes*.

872. *Ord. Acanthaceæ (Acanthus Family)*. Herbs or shrubby plants, with bracteate showy flowers, and opposite simple leaves, without stipules. Corolla bilabiate, or sometimes almost regularly

five-lobed, convolute in æstivation! Stamens four and didynamous, or only two, the anterior pair being abortive or obsolete. Ovary two-celled, with the placenta in the axis, often few-ovuled. Seeds (sometimes only one or two in each cell) usually supported by hooked processes of the placenta, destitute of albumen. The classical *Acanthus* is the type of this large and chiefly tropical order: its gracefully lobed and sinuated leaves furnished the ornament of the Corinthian capital. They are emollient plants, or some of them bitter or slightly acrid: of little economical use. Several are cultivated for ornament.

873. Ord. Scrophulariaceæ (*Figwort Family*). Herbs, or sometimes shrubby plants, with opposite, verticillate, or alternate leaves.



Corolla bilabiate, or more or less irregular; the lobes imbricated in æstivation. Stamens four and didynamous (Fig. 407), the fifth or upper stamen sometimes appearing in the form of a sterile filament

FIG. 971. Branch of *Gerardia purpurea*. 972. Corolla, of the natural size, laid open. 973. Calyx and style of the same. 974. Magnified transverse section of the capsule, with one of the valves removed.

FIG. 975. *Gratiola aurea*, natural size. 976. Corolla laid open, showing the two perfect stamens and two rudimentary filaments as well as the pistil. 977. The perfect stamens and sterile filament of *Chelone*. 978. Flower of a *Linaria* (Toadflax).

(Fig. 408), or very rarely antheriferous, or often only two, one pair being either suppressed or reduced to sterile filaments. Ovary free, two-celled, with the placenta united in the axis. Capsule two-valved. Seeds indefinite, or sometimes few, albuminous. Embryo small. — *Ex.* Scrophularia, Verbascum (Mullein, which is remarkable for the almost regular corolla, and the five often nearly perfect stamens), Linaria, Antirrhinum (Snapdragon), &c. — The plants of this large and important order are generally to be suspected of deleterious (bitter, acrid, or drastic) properties. The most important medicinal plant is the Foxglove (*Digitalis purpurea*), so remarkable for its power of lowering the pulse. Numerous species are cultivated for ornament.

874. Ord. *Verbenaceæ* (*Vervain Family*). Herbs, shrubs, or often trees in the tropics, mostly with opposite leaves. Corolla bilabiate, or the four- or five-lobed limb more or less irregular. Stamens mostly four and didynamous, occasionally only two. Ovary free,



entire, two- to four-celled. Fruit drupaceous, baccate, or dry, and splitting into two to four indehiscent one-seeded portions. Seeds with little or no albumen. Embryo straight, inferior. — *Ex.* *Verbena* (Vervain) is the principal representative in cooler regions. There are many others in the tropics; one of which is the gigantic Indian Teak (*Tectona grandis*), remarkable for its very heavy and durable

FIG. 979 and 980. Flower of a *Verbena* enlarged. 981. The corolla laid open. 982. Pistil. 983. The fruit. 984. Cross-section of the young fruit and the contained seeds. 985. Fruit separating into its four cocci. 986. Cross-section of one of the cocci, and a vertical section of the lower part, showing the surface of the contained seed. 987. Vertical section through the pericarp, seed, and embryo.

wood. The leaves of *Lippia citridora* of the gardens yield an agreeable perfume. Others are bitter and aromatic.

875. Subord. ? *Phrymaceæ* (founded on *Phryma*, of a single species) is separated on account of its simple pistil, uniovulate ovary, spirally convolute cotyledons, and superior radicle.

876. Ord. *Labiata* (*Labiata* or *Mint Family*). Herbs, or somewhat shrubby plants, with quadrangular stems, and opposite or sometimes whorled leaves, replete with receptacles of volatile oil. Flowers in axillary cymes, rarely solitary. Corolla bilabiate (Fig. 458). Stamens four, didynamous, or only two, one of the pairs being abortive or wanting. Ovary free, deeply four-lobed; the central style proceeding from between the lobes. Fruit consisting of four (or fewer) little nuts or achenia, included in the persistent calyx. Seeds with little or no albumen.—*Ex.* The Sage, Rose-



mary; Lavender, Thyme, Mint, &c. are familiar representatives of this universally recognized order. Their well-known cordial, aromatic, and stomachic qualities depend upon a volatile oil, contained in glandular receptacles which abound in the leaves and other herbaceous parts, with which a bitter principle is variously mixed.

877. Ord. *Borraginaceæ* (*Borage Family*). Herbs, or sometimes shrubby plants, with round stems, and alternate rough leaves; the

FIG. 988. Flower of *Nepeta* (*Glechoma*) *hederacea*, or Ground Ivy. 989. Approximate anthers of one pair of stamens, magnified. 990. Flower of a *Lamium*. 991. Corolla of *L. amplexicaule* (Dead Nettle), laid open, showing the didynamous stamens, &c. 992. Calyx and corolla of *Scutellaria galericulata* (Skull-cap). 993. Section of the enlarged calyx of the same, bringing to view the deeply four-lobed ovary. 994. Cross-section of a magnified achenium. 995. Vertical section of the same, showing the embryo. 996. Flower of *Teucrium Canadense*. 997. Magnified anther of the same. 998. Stamen of the Thyme. 999. Flower of *Monarda*. 1000. Magnified anther of the same. 1001. Flower of a *Salvia*; the calyx as well as the corolla bilabiate. 1002. Magnified stamen of the same, with widely separated anther-cells, one of which (a) is polliniferous, the other (b) imperfect.

flowers often in one-sided scorpioid clusters (407). Calyx of five leafy and persistent sepals, more or less united at the base, regular. Corolla regular; the limb five-lobed, often with a row of scales in the throat. Stamens as many as its lobes and alternate with them. Ovary deeply four-lobed, the style proceeding from the base of the lobes, which in fruit become little nuts or hard achenia. Seeds with little or no albumen. — *Ex.* Borage, *Lithospermum*, *Myosotis*, *Cynoglossum* (Hound's-Tongue), *Heliotropium*, &c. In *Echium*, the limb of the corolla is somewhat irregular, and the stamens unequal. Innocent mucilaginous plants with a slight astringency: hence demulcent and pectoral; as the roots of the Comfrey. The roots of *An-*



chusa tinctoria (Alkanet) and *Lithospermum canescens*, &c. (used by the aborigines under the name of Puccoon) yield a red dye.

878. Subord. ? *Cordiaceæ* consists of tropical woody plants, with the ovary entire (not four-lobed), but in fruit drupaceous or dry and indehiscent, four-seeded. The cotyledons of *Cordia* are plaited longitudinally (and are often edible), and the style is twice forked.

879. Ord. *Hydrophyllaceæ* (*Water-leaf Family*). Herbs, usually with alternate and lobed or pinnatifid leaves; the flowers mostly in cymose clusters or unilateral racemes. Calyx five-cleft, with the

* FIG. 1003. *Myosotis*, or Forget-me-not. 1004. The rotate corolla laid open, showing the scales of the throat, and the short stamens. 1005. The pistil, with its four-lobed ovary. 1006. The calyx in fruit; two of the little nuts having fallen away from the receptacle. 1007. Section of a nut, or rather achenium, showing the embryo. 1008. Raceme of *Symphytum officinale* (Comfrey). 1009. A corolla laid open; exhibiting the lanceolate and pointed scales of the throat, alternate with the stamens.

sinuses often appendaged, persistent. Corolla regular, imbricated or convolute in æstivation, usually furnished with scales or honey-bearing grooves inside; the five stamens inserted into its base, alternate with the lobes. Ovary free, with two parietal placenta, which in *Hydrophyllum* dilate in the cell and appear like a kind of inner peri-



carp in the capsular fruit. Styles partly united. Seeds few, or sometimes numerous, amphitropous, crustaceous. Embryo small, in hard albumen. — *Ex.* *Hydrophyllum*, *Nemophila*, and *Phacelia*; nearly all North American plants, some of them handsome and now well known in cultivation. To this order, as a tribe, is now joined the *HYDROLEÆ* (formerly the order *Hydroleaceæ*), having often entire leaves, two distinct styles, a commonly two-celled ovary by the union of the two placenta in the axis, and numerous seeds with a fleshy albumen. These are chiefly tropical or subtropical herbs, or low shrubs.

FIG. 1010. *Hydrophyllum Virginicum*. 1011. A flower, nearly of the natural size. 1012. Corolla laid open. 1013. Capsule, with the persistent calyx and style. 1014. Magnified seed. 1015. Section of the same. 1016. Highly magnified embryo.

880. Ord. Polemoniaceæ (*Polemonium* Family). Herbs, with alternate or opposite leaves, and paniced, corymbose, or clustered flowers.



ers. Calyx five-cleft. Corolla regular, with a five-lobed limb, convolute in aestivation. Stamens five, inserted on the corolla alternate



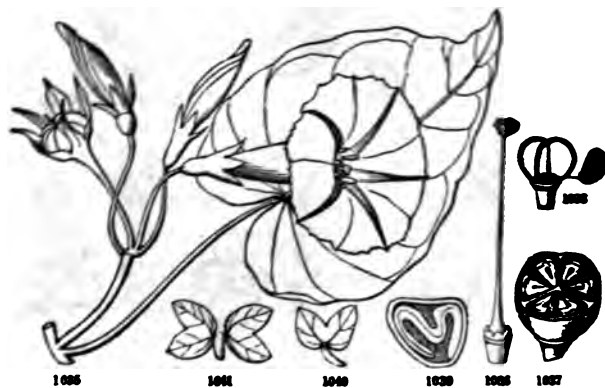
with its lobes, often unequal. Ovary free, three-celled, with a thick

FIG. 1017. Flowers of *Polemonium*. 1018. Flowers of *Phlox*. 1019. Corolla of the same, laid open, showing the stamens unequally inserted on its tube. 1020. Pistil of the same. 1021. Cross-section of the capsule of *Polemonium*. 1022. Cross-section of a magnified seed. 1023. Perpendicular section of the same. 1024. Magnified embryo. 1025. Cross-section of the dehiscent capsule of *Collomia*. 1026, 1027. Capsule of *Leptodactylon*.

FIG. 1028. *Pyridanthera barbulata*, of the Pine-barrens of New Jersey, natural size. 1029. Pistil, in fruit, and calyx, enlarged. 1030. Corolla and stamens. 1031. Same, laid open. 1032. A separate stamen, magnified. 1033. Section of the dehiscent capsule. 1034. A seed.

axis bearing few or numerous ovules: styles united into one: stigmas three. Capsule three-valved, loculicidal: the valves also usually breaking away from a thick central column which bears the seeds. Embryo straight in fleshy or horny albumen. — *Ex.* Polemonium (Greek Valerian), Phlox, Gilia. Chiefly North American; many are very common ornamental plants in cultivation. To this order Diapensiaceae and Pyxidanthaceae (formerly the order *Diapensiaceae*) are now appended, with some doubt. They are two low, tufted or prostrate, suffruticose plants, with crowded and evergreen, beech-like leaves, and solitary flowers: their principal peculiarity is found in the transversely dehiscent anthers.

831. *Ord. Convolvulaceae (Convolvulus Family).* Twining or trailing herbs or shrubs, with more or less milky juice; the leaves alternate, and the flowers regular. Calyx of five imbricated sepals, persistent. Corolla supervolute in aestivation; the limb often entire (Fig. 452). Stamens five, inserted on the tube of the corolla near the base. Ovary free, two- to four-celled, with one or two erect ovules in each cell. Capsule two- to four- (or by obliteration one-) celled; the valves often falling away from the persistent dissepiments (septifragal, Fig. 587). Seeds large, with a little mucilaginous albumen: embryo curved, and the foliaceous cotyledons usually



crumpled (Fig. 122, 123). — *Ex.* Morning-Glory, Bindweed. They contain a peculiar strongly purgative resinous matter, which is

FIG. 1036. *Ipomoea purpurea*. 1036. The pistil. 1037. Section of the capsule, and of the two seeds in each cell. 1038. Capsule (reduced in size), when the valves have fallen away from the dissepiments; and one of the seeds. 1039. Magnified cross-section of a seed. 1040. Embryo, with the leaf-like two-lobed cotyledons spread out. 1041. Same, with the two cotyledons separated and laid open.

chiefly found in their thickened or tuberous roots. *Convolvulus Jalapa*, and other Mexican species, furnish the *Jalap* of the shops. The more drastic *Scammony* is derived from the roots of *C. Scammonia* of the Levant. There is much less of this in those of *Convolvulus panduratus* (Man-of-the-Earth, Wild Potato-vine): while those of *C. macrorhizus* of the Southern States, which sometimes weigh forty or fifty pounds, are farinaceous, with so slight an admixture of this matter as to be quite inert; as is also the case with the Batatas, or Sweet Potato, an important article of food. — To this family are appended, as tribes or suborders,

882. Subord. *Dichondrææ*. Ovaries two to four, either entirely distinct or with their basilar styles more or less united in pairs. Creeping plants, with axillary, scape-like, one-flowered peduncles. — *Ex. Dichondra*.

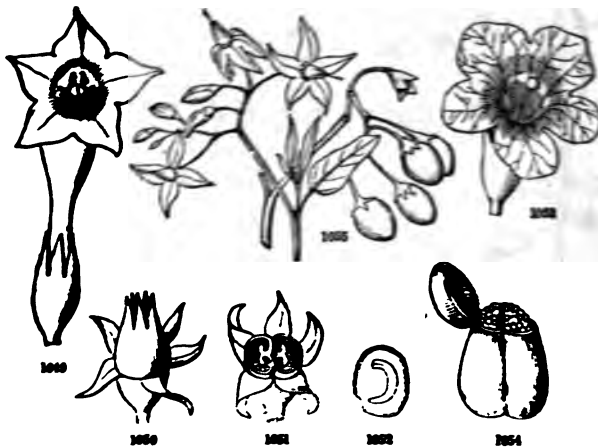
883. Subord. *Cuscutinææ*. Ovary two-celled; the capsule opening by circumscissile dehiscence, or bursting irregularly. Embryo filiform, and spirally coiled in fleshy albumen, destitute of cotyledons!



Parasitic, leafless, twining herbs, destitute of green color. Stamens usually furnished with fringed scales within. — *Ex. Cuscuta* (Dodder).

FIG. 1042. A piece of *Cuscuta Gronovii*, the common Dodder of the Northern United States, of the natural size. 1043. A flower, enlarged. 1044. The same, laid open. 1045. Section of the ovary. 1046. Section of the capsule and seeds. 1047. The spiral embryo detached. 1048. The same in germination.

884. *Ord. Solanaceæ (Nightshade Family)* differs from *Scrophulariaceæ* chiefly in the regular (rarely somewhat irregular) flowers, with as many fertile stamens as there are lobes to the corolla (four or five), and some form of the plaited or valvate aestivation of the corolla. Fruit either capsular or baccate. Embryo slender, mostly curved, in fleshy albumen (Fig. 614, 615).—The fruit of *Datura* is spuriously four-celled.—Stimulant narcotic properties pervade the order, the herbage and fruits of which are mostly deleterious, often violently poisonous, and furnish some of the most active medicines; such as the Tobacco, the Henbane (*Hyoscyamus niger*), the

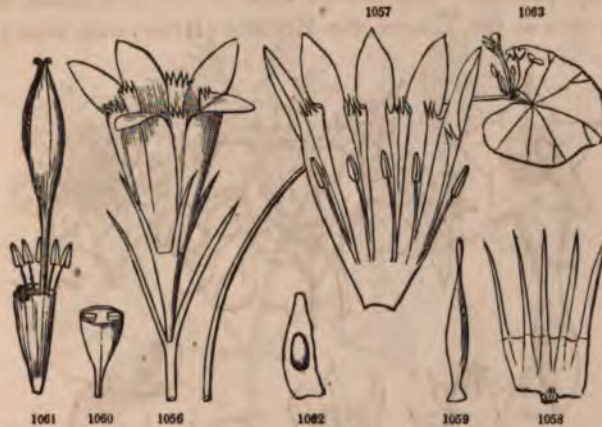


Belladonna (*Atropa Belladonna*), the Thorn-apple or Jamestown Weed (*Datura Stramonium*), and the Bittersweet (*Solanum Dulcamara*). Yet the berries of some *Solanums* are eatable (as Tomatoes, the Egg-Plant, &c.), and the starchy tubers of the Potato are a great staple of food. But the fruit and seeds of *Capsicum* (*Cayenne pepper*) are most pungent and stimulant.

885. *Ord. Gentianaceæ (Gentian Family)*. Herbs, with a watery juice; the leaves opposite and entire. Flowers regular, often showy. Calyx of usually four or five persistent, more or less united sepals. Corolla mostly convolute in aestivation; the stamens inserted on its tube. Ovary one-celled, with two parietal and many-ovuled pla-

FIG. 1049. Flower of Tobacco (*Nicotiana Tabacum*). 1050. The capsule, dehiscent at the apex, with the persistent calyx. 1051. Cross-section of the same. 1052. Magnified section of the seed of *Solanum*. 1053. Flower of *Hyoscyamus niger*. 1054. Fruit (pyxis) of the same. 1055. Flowers and berries of *Solanum Dulcamara*.

centre, sometimes the ovules dispersed over the whole cavity of the ovary, or nearly so. Capsule many-seeded. Seeds often very small, with fleshy albumen and a minute embryo. — *Ex.* *Gentiana*, *Frasera* (the American Columbo). A pure bitter and tonic principle (*Gentianine*) pervades the whole order. *Gentiana lutea* of Middle Europe furnishes the officinal *Gentian*, for which almost any of our species may be substituted. The above applies to the proper *Gentian* Family. *Obolaria* differs in the imbricative æstivation of the

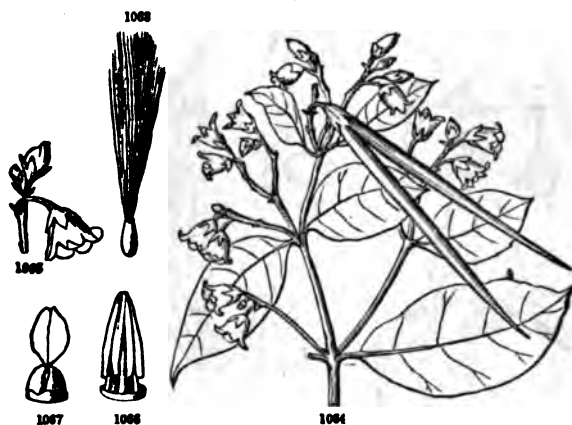


corolla: as to the ovules lining the whole cavity of the ovary, this is also the case in *Bartonia* (*Centaurella*, *Michx.*), and in some *Gentians*. — The Buckbean is the type of the tribe *MENYANTHIDEÆ*, which has alternate, sometimes trifoliate or toothed leaves, and a valvate-induplicate æstivation of the corolla.

886. *Ord. Apocynaceæ (Dogbane Family).* Trees, shrubs, or herbs, with milky juice, and opposite entire leaves, without stipules. Flowers regular. Corolla five-lobed, mostly convolute or twisted in æstivation. Filaments distinct; the anthers sometimes slightly connected: pollen powdery. Ovaries two, distinct, or rarely syncarpous, but their styles or stigmas combined into one. Fruit commonly a pair of two follicles. Seeds often with a coma. Embryo large and straight, in albumen. — *Ex.* *Apocynum* (*Dogbane*), *Vinca*

FIG. 1056. Flower of *Gentiana angustifolia*. 1057. Corolla, and 1058, the calyx, laid open. 1059. The pistil. 1060. Cross-section of the pistil, showing the parietal attachment of the ovules. 1061. Ripe capsule of *G. saponaria*, raised on a stipe: the persistent withering corolla, &c torn away. 1062. A magnified seed, with its large and loose testa. 1063. Leaf of *Limnanthemum lacunosum*, bearing the flowers on its petiole!

(Periwinkle), Nerium (Oleander), and a great number of tropical shrubs and trees. In nearly all, the juice is drastic or poisonous; it often yields *Caoutchouc*; which in Sumatra is obtained from *Urceola elastica*, and in Madagascar from *Vahea*. Strangely enough some species yield a sweet and harmless milk, such as *Tabernaemontana utilis*, one of the South American Cow-trees. Also the fruit of several species is edible and even delicious; that of others is a deadly poison. One kernel of *Tanghinia venenifera* of Mad-



agascar will kill twenty people. The inner bark of Dogbane makes a strong cordage, whence its name of Indian Hemp.

887. Ord. *Asclepiadaceæ* (*Milkweed Family*). Herbs or shrubs, with milky juice, and mostly opposite entire leaves; mainly differing from the preceding order (as they do from all other Exogenous plants) by the peculiar connection of the stamens with the stigma, and the cohesion of the pollen into wax-like or granular masses, which are attached in pairs to five glands of the stigma, and removed from the anther-cells usually by the agency of insects (Fig. 541–545). Fruit consisting of two follicles. Seeds usually with a silky coma and a large embryo. — *Ex.* *Asclepias* (Milkweed, or Silkweed). The juice of the *A. tuberosa* (Pleurisy-root, Butterfly-weed) is not milky. In all, it is bitter and acrid, and contains *Caoutchouc*. The roots, &c. are diaphoretic, emetic, or cathartic. The inner bark yields abundance of very long and fine, extremely

FIG. 1064. *Apocynum androsaemifolium*. 1065. Flower, of the natural size. 1066. Stamens with the anthers connivent around the pistils. 1067. The pistils with their large common stigma. 1068. Seed with its coma, or tuft of silky hairs.

strong fibres. The singular structure of the blossom may be learned from Fig. 541–545, and the subjoined illustrations.



888. Ord. *Jasminaceæ* (*Jessamine Family*) consists of a few chiefly Asiatic shrubs, with compound leaves and fragrant flowers; differing from *Oleaceæ* by the imbricated or twisted aestivation of the hypocrateriform corolla, the erect seeds, &c.—*Ex.* *Jasminum*, the Jessamine. Cultivated for ornament, and for their very fragrant blossoms.—*Menodora*, or *Bolivaria*, has mostly simple leaves and four ovules in each cell, but evidently pertains to this order.

889. Ord. *Oleaceæ* (*Olive Family*). Trees or shrubs, with opposite leaves, either simple or pinnate. Calyx persistent. Corolla

FIG. 1069. Flower-bud of the common Milkweed (*Asclepias Cornuti*). 1070 Expanded flower; the calyx and corolla reflexed; showing the staminal crown. 1072. One of the hooded appendages of the latter removed and seen sidewise, with its included process or horn. 1073. A vertical section of a flower (the hooded appendages removed) through the tube of stamens, the thick stigma, ovaries, &c. 1074. Flower with the calyx and the fertilized enlarging ovaries, crowned with the large stigma common to the two, from the angles of the peltate summit of which the pairs of pollen-masses, detached from the anther cells, hang by their stalks or caudicle from a gland. 1075. Fruit (follicle) of the Common Milkweed. 1076. Cross-section of the last, in an early state. 1077. Detached placenta in fruit, covered with seeds. 1078. Seed (cut across), with its coma. 1079. Section of the seed, parallel with the cotyledons. 1080. Vertical section of the seed perpendicular to the face of the cotyledons.

four-cleft, or of four separate petals, valvate in æstivation, sometimes none. Stamens mostly two, adnate to the base of the corolla. Ovary free, two-celled, with two pendulous ovules in each cell. Fruit by suppression usually one-celled and one- or two-seeded. Seed albuminous. Embryo straight. — *Ex.* *Olea* (the Olive), and *Chionanthus* (Fringe-tree), where the fruit is a drupe. *Syringa*, the Lilac, which has a capsular fruit. *Fraxinus*, the Ash; where the fruit is a samara, the flowers are polygamous, and mostly destitute of petals. *Olive oil* is expressed from the esculent drupes of *Olea Europæa*. The bark, like that of the Ash, is bitter, astringent, and febrifugal. *Manna* exudes from the trunk of *Fraxinus Ornus* of Southern Europe, &c. — *Forestiera* appears to represent another entirely apetalous form of this family.

Division III. — APETALOUS EXOGENOUS PLANTS.

Corolla none; the floral envelopes consisting of a single series (calyx), or sometimes entirely wanting. — Many of them are apetalous allies of polypetalous families; as *Phytolaccaceæ*, &c. related to *Caryophyllaceæ*; *Empetraceæ* to *Ericaceæ*, &c.

CONSPECTUS OF THE ORDERS.

Group 1. Flowers perfect, with a conspicuous or colored mostly adnate calyx.

Ovary several-celled and many-ovuled. Capsule or berry many-seeded. —
Herbs or climbing shrubs. ARISTOLOCHIACEÆ.

Group 2. Flowers perfect, or rarely polygamous. Calyx corolline, strongly gamosepalous, much produced beyond the ovary, the expanded border entire or moderately lobed; the base persistent, and forming an indurated nut-like closed covering to the one-seeded achenium or utricle. Embryo large, curved or conduplicate, involving some albumen. — Leaves opposite: nodes tumid. Flowers often large and showy. NYCTAGINACEÆ.

Group 3. Flowers perfect, or rarely polygamous, with a regular and often petaloid calyx. Ovary free. Ovules solitary in each ovary or cell. Embryo curved or coiled around (or sometimes in) mealy albumen, rarely in the axis or exalbuminous.

Ovary several-celled, or ovaries several in a whorl.

PHYTOLACCACEÆ.

Ovary solitary and one-celled, with a single ovule.

Stipules none. Ovule campylotropous or amphitropous.

- Calyx corolline, double. Stamens perigynous. BASELLACEÆ.
 Calyx not corolline: no scarious bracts. CHENOPODIACEÆ.
 Calyx and bracts scarious, sometimes colored. AMARANTACEÆ.
 Stipules sheathing. Calyx corolline. Ovule orthotropous. POLYGONACEÆ.
- Group 4.* Flowers perfect, polygamous or diœcious, not disposed in aments, with a regular and often petaloid calyx. Style or stigma one. Ovary one-celled, with one or few ovules: but the fruit one-celled and one-seeded. Embryo not coiled around albumen. — Trees or shrubs, rarely herbs.
- Calyx free from the ovary, and not enveloping the fruit.
 Flowers polygamo-diœcious. Anthers opening by valves. LAURACEÆ.
 Flowers perfect. Anthers opening longitudinally. THYMELACEÆ.
 Calyx free, but baccate in fruit and enclosing the achenium. ELEAGNACEÆ.
 Calyx adnate to the ovary. Ovule destitute of coats.
 Ovules several, pendulous from a stipe-like placenta. SANTALACEÆ.
 Ovule solitary, suspended. Parasitic shrubs. LORANTHACEÆ.
- Group 5.* Flowers perfect, in spikes which often appear like aments, achlamydeous. Ovaries solitary or several, with one or few erect or ascending orthotropous ovules. Embryo minute, enclosed in a persistent embryo-sac at the apex of the albumen. — Herbs or shrubby plants, with tumid nodes.
- Ovary one, one-ovuled. Stipule opposite the leaf or none. PIPERACEÆ.
 Ovaries more than one. Stipules, when present, in pairs. SAURURACEÆ.
- Group 6.* Flowers perfect or diœcious, frequently destitute of both calyx and corolla. — Submersed or floating aquatic herbs.
- Flowers monœcious. Fruit one-celled, one-seeded. CERATOPHYLLACEÆ.
 Flowers mostly perfect. Fruit four-celled, four-seeded. CALLITRICHACEÆ.
 Flowers mostly perfect. Pod several-celled, several-seeded. PODOSTEMACEÆ.
- Group 7.* Flowers monœcious or diœcious, not amentaceous. Fruit capsular or drupaceous, with two or more cells, and one (or rarely two) seeds in each cell. Embryo straight in the axis of the albumen. — Herbs, shrubs, or trees.
- Fruit mostly dry. Juice milky. Pollen simple. EUPHORBIACEÆ.
 Fruit drupaceous. Pollen compound; the grains in fours. EMPETRACEÆ.
- Group 8.* Flowers monœcious, diœcious, or polygamous, with a regular calyx which is free from the one-celled (or rarely two-celled) ovary and one-seeded fruit (achenium, drupe, or samara), but sometimes enclosing it. Embryo curved, or straight, with the radicle superior, in albumen when there is any. — Inflorescence various, often in spikes, heads, or a sort of aments. URTICACEÆ.
- Group 9.* Flowers monœcious or diœcious, the sterile, and frequently the fertile also, in aments, or in heads or spikes. Calyx of the fertile flowers, if any, adherent. Ovary often two- to several-celled, but the fruit always one-celled. — Trees or shrubs.

Stipules sheathing. Nutlets club-shaped, in globular heads. **PLATANACEÆ**
 Stipules not sheathing or none.

Sterile flowers only amentaceous.

Fruit a kind of drupaceous nut. Leaves pinnate. **JUGLANDACEÆ.**

Fruit a dry nut, involucrate. Leaves simple. **CUPULIFERÆ.**

Both kinds of flowers amentaceous.

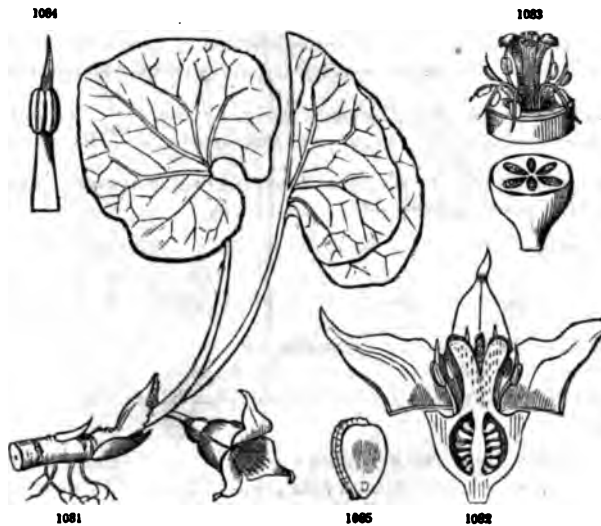
Fruit a samara or a small dry drupe.

Ovary one-celled : ovule solitary, erect. **MYRICACEÆ.**

Ovary two-celled, two-ovuled : ovule pendulous. **BETULACEÆ.**

Fruit a many-seeded follicle : seeds with a coma. **SALICACEÆ.**

890. Ord. *Aristolochiaceæ* (*Birthwort Family*). Herbaceous or climbing shrubby plants, with alternate leaves. Flowers brown or greenish, usually solitary. Calyx-tube more or less united with the ovary ; the limb valvate. Stamens six to twelve, epigynous, or adherent to the base of the short and thick style : anthers adnate,



extrorse. Ovary 8-6-celled. Capsule or berry three- to six-celled, many-seeded. Embryo minute, in fleshy albumen. — *Ex.* *Asarum* (Wild Ginger, Canada Snakeroot), *Aristolochia* (Virginia Snake-root). Pungent, aromatic, or stimulant tonics ; generally termed Snakeroots, being reputed antidotes for the bites of venomous snakes.

FIG. 1081. *Asarum Canadense*. 1082. Calyx displayed, and a vertical section through the rest of the flower. 1083. Cross-section of the ovary ; the upper portion (from which the limb of the calyx is cut away) showing the stamens, the united styles, &c. 1084. A separate stamen, enlarged. 1085. Vertical section of a seed.

891. Ord. *Rafflesiaceæ*: parasitic flowers, or flower-clusters (152), of which the most striking is the gigantic *Rafflesia Arnoldi* of Sumatra (Fig. 150); perhaps as much related to the last order as to any.

892. Ord. *Nyctaginaceæ* (*Four-o'clock Family*). Herbs or shrubs, with opposite leaves; distinguished by their tubular and funnel-form calyx, the upper part of which resembles a corolla, and at length separates from the base, which latter hardens and encloses the one-celled achenium-like fruit, appearing like a part of it. Stamens hypogynous, 1–20. Embryo coiled around mealy albumen (Fig. 616, 617); cotyledons large. Flowers involucrete. *Mirabilis* (*Four-o'clock*) has a one-flowered involucre exactly like a calyx, while the real calyx resembles the corolla of a *Morning-Glory*. *Abronia* has only one cotyledon to its embryo! — Plants of warm latitudes; many occur on our Southwestern frontiers.



893. Ord. *Phytolaccaceæ* (*Poke-weed Family*). Chiefly represented

FIG 1086, 1087. *Phytolacca decandra* (Pokeweed). 1088. A flower. 1089. Unripe fruit. 1090. Cross-section of the same, a little enlarged. 1091. Magnified seed. 1092. Section of the same across the embryo. 1093. Vertical section, showing the embryo coiled around the albumen into a ring. 1094. Magnified detached embryo.

by the common Poke (*Phytolacca decandra*), which has a compound ovary of ten confluent (one-seeded) carpels, the short styles or stigmas distinct; the fruit a berry. The root is acrid and emetic: yet the young shoots in the spring are used as a substitute for *Asparagus*. The berries yield a copious deep-crimson juice.

894. Ord. *Basellaceæ*; a small subtropical group of climbing succulent plants, allied to the last and the next two orders, from which it differs by the decidedly perigynous stamens and double petaloid calyx. The ovary is single and one-ovuled. — *Ex.* *Basella*, *Boussingaultia* of South America; the latter cultivated for ornament (from potato-like tubers) under the name of Madeira Vine. Some are pot-herbs.

895. Ord. *Chenopodiaceæ* (*Goosefoot Family*). Chiefly weedy herbs, with alternate or opposite and more or less succulent leaves,

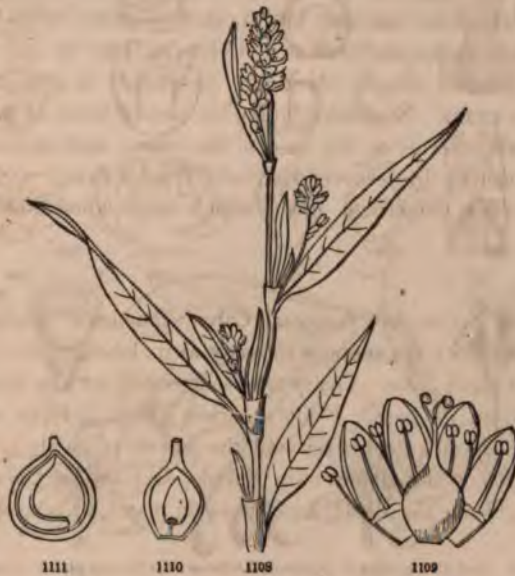


and small herbaceous flowers. Calyx sometimes tubular at the base, persistent; the stamens as many as its lobes, or fewer, and inserted at their base. Ovary free, one-celled, with a single ovule arising from its base. Fruit a utricle (Fig. 574) or achenium. Embryo curved or coiled around the outside of mealy albumen, or spiral without any albumen (in *Salsola*, &c.). — *Ex.* *Chenopodium*, *Atriplex*, *Beta* (the Beet), &c. Sea-side plants, or common weeds:

FIG. 1095. Part of the spike of *Salicornia herbacea*: the flowers placed three together in excavations of the stem, protected by a fleshy scale. 1096. Separate flower. 1097. A flower of *Blitum*, with its fleshy calyx and single stamen. 1098. Same, more enlarged, with the thickened juicy calyx (1099) removed. 1100. The ripe fruit. 1101. Same, divided vertically, showing the embryo coiled around the central albumen. 1102. Flower of *Chenopodium album* (common Goosefoot). 1103. Section of the same, more enlarged. 1104. Section of the utricle and seed, showing the embryo. 1105. Calyx of *Salsola kali* (Saltwort), in fruit, with its wing-like border. 1106. Section of the same, bringing the ovary into view. 1107. The spirally coiled embryo of *Chenopodium maritima*.

some are pot-herbs, such as Spinach: a few are cultivated for their esculent roots; as the Beet, which yields sugar. Soda is extracted from the maritime species, especially from those of *Salsola* and *Salicornia* (Samphire, Glass-wort). *Chenopodium anthelminticum* yields the well-known *Worm-seed oil*.

896. Ord. *Amarantaceæ* (*Amaranth Family*). Flowers in heads, spikes, or dense clusters, imbricated with dry and scarious bracts which are often colored. Calyx of three to five sepals, which are dry and scarious like the bracts. Stamens five or fewer, hypogynous, distinct or monadelphous: anthers frequently one-celled. Utricle often opening as a pyxis (Fig. 575). Embryo annular, always vertical. Otherwise nearly as in *Chenopodiaceæ*.—*Amarantus*, &c. A few *Amaranth*s (*Coxcomb*, &c.) and *Globe Amaranth* (*Gomphrena*) are cultivated for ornament. But most of the family are coarse and homely weeds (*Pigweeds*, &c.).

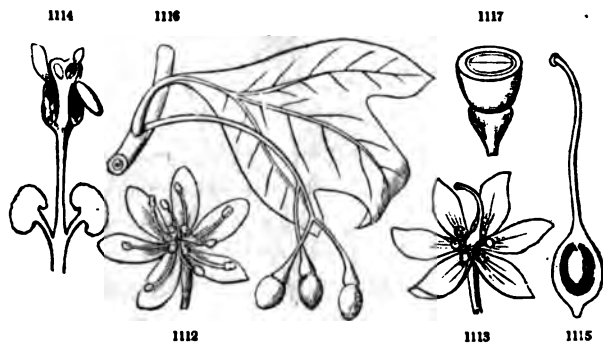


897. Ord. *Polygonaceæ* (*Buckwheat Family*). Herbs with alternate leaves; remarkable for their stipules (ochreae, Fig. 305), which

FIG. 1108. *Polygonum pennsylvanicum*. 1109. Flower, laid open. 1110. Section of the ovary, showing the erect ovule. 1111. Section of the seed, showing the embryo, at one side of albumen.

usually form sheaths around the stems above the leaves, and for their orthotropous ovules (Fig. 518, 526). Stamens definite, inserted on the petaloid calyx. Fruit achenium-like. Embryo curved, or nearly straight, applied to the outside (rarely in the centre) of starchy albumen (Fig. 606).—*Ex.* Polygonum, Rumex (Dock, Sorrel), Rheum (Rhubarb). The stems and leaves of Rhubarb and Sorrel are pleasantly acid: while several Polygonums (Knot-weed, Smart-weed, Water Pepper, &c.) are acrid or rubefacient. The farinaceous seeds of *P. Fagopyrum* (the Buckwheat) are used for food. The roots of most species of *Rhubarb* are purgative: but it is not yet known what particular species of Tartary yields the genuine officinal article. The ERIOGONEÆ (a large tribe of the southern and western parts of North America, chiefly west of the Rocky Mountains) are remarkable for their exstipulate leaves and involucrate flowers.

898. Ord. Lauracæ (*Laurel Family*). Trees or shrubs, with pellucid-punctate alternate leaves, their margins entire. Flowers sometimes polygamo-diœcious. Calyx of four to six somewhat united petaloid sepals, which are imbricated in two series, free from the ovary. Stamens definite, but usually more numerous than the sepals, inserted on the base of the calyx: anthers two- to four-celled, opening by recurved valves! Fruit a berry or drupe, the pedicel often thickened. Seed with a large almond-like embryo,



destitute of albumen.—*Ex.* *Laurus*, *Sassafras*, *Benzoin*. All aromatic plants, almost every part abounding in warm and stimulant

FIG. 1112. A staminate, and 1113, a pistillate flower of *Sassafras*. 1114. A stamen with its glands at the base: the anthers opening by two sets of valves. 1115. Pistil; the ovary divided. 1116. Branch in fruit. 1117. Section of the drupe and seed.

volatile oil, to which their qualities are due. *Camphor* is obtained from *Camphora officinarum* of Japan, China, &c. *Cinnamon* is the bark of *Cinnamomum Zeylanicum*; *Cassia bark*, of *Cinnamomum aromaticum* of China. The aromatic bark and wood and the very mucilaginous leaves of our own *Sassafras* are well known. Our *Benzoin odoriferum* is the Spice-wood, or Feverbush. *Laurus nobilis* is the true Laurel, or Sweet Bay. *Persea gratissima*, of the West Indies, bears the edible Avocado pear.

899. Ord. *Thymelacæ* (*Mezereum Family*). Shrubby plants, with perfect flowers, and a very tough bark; the tube of the petaloid calyx being free from the (one-ovuled) ovary; its lobes imbricated in æstivation; the pendulous seed destitute of albumen. Stamens often twice as many as the lobes of the calyx, inserted upon its tube



or throat.—*Ex.* *Daphne* and *Dirca* (Leather-wood, Moose-wood, Wickopy, which is the only North American genus). The tough bark is acrid, or even blistering, and is also useful for cordage. The reticulated fibres of the liber in the *Lagetta* or *Lace-bark* of Jamaica may be separated into a kind of lace. The berries are more or less deleterious.

900. Ord. *Eleagnaceæ* (*Oleaster Family*). Shrubs or small trees, with the flowers more commonly diœcious; readily distinguished from the preceding by having the foliage and shoots covered with scurf, by the ascending albuminous seed, and the persistent tube of

FIG. 1118. Flowering branch of *Dirca palustris*. 1119. A flower. 1120. The same, laid open and enlarged. 1121. Branch in fruit.

the calyx, which, although free from the ovary, becomes succulent, like a berry in fruit, and constricted at the throat, enclosing the crustaceous achenium. — *Ex.* *Eleagnus*, *Shepherdia*. Plants of no economical importance, except that a few are cultivated for their silvery foliage. The fruit is sometimes eaten, as is that of the Buffalo-berry (*Shepherdia argentea*) and Silver-berry (*Eleagnus argentea*) by the Northern aborigines.

901. *Ord. Proteaceæ (Protea Family)*. A rather large family of shrubs and trees of Southern temperate and subtropical regions, chiefly of the Cape of Good Hope and Australia (a few in South America, &c.), with rigid coriaceous leaves, perfect flowers, either regular or irregular, mostly in heads or spikes; the lobes of the calyx valvate in æstivation; a stamen borne on each of its four lobes; the pistil simple and free, forming a mostly dehiscent fruit; seeds with a large and straight embryo, and no albumen. Many of these plants are prized in conservatories for their beauty or singularity: the seeds of a few species are eaten.

902. *Ord. Santalaceæ (Sandal-wood Family)*. Trees, shrubs, or sometimes herbs (their roots inclined to form parasitic attachments); with alternate entire leaves, and small (very rarely diœ-



cious) flowers. Calyx-tube adherent to the ovary; the limb four- or five-cleft, valvate in æstivation; its base lined with a fleshy disk, the edge of which is often lobed. Stamens as many as the lobes of

FIG. 1122. Branch of *Comandra umbellata*. 1123. Enlarged flower, laid open. 1124. Vertical section of a flower. 1125. One of the segments of the calyx, enlarged, showing the tuft of hairs which connects its surface with the anther! 1126. The fruit, reduced in size.

the calyx, and opposite them, inserted on the edge of the disk. Ovules several, destitute of proper integuments, pendulous from the apex of a stipe-like basilar placenta. Style one. Fruit indehiscent, crowned with the limb of the calyx. Seed albuminous. Embryo small. — *Ex.* Comandra, Pyrularia, &c. The fragrant *Sandal-wood* is obtained from several Indian and Polynesian species of Santalum. The large seeds of Pyrularia oleifera (Buffalo-tree, Oil-nut), of the Alleghany Mountains, would yield a copious fixed oil. One species of Fusanus in Australia is esteemed for its edible seeds, known by the name of *Quandang-nuts*.

903. Ord. Loranthaceæ (*Mistletoe Family*) consists of shrubby plants, with articulated branches, and opposite coriaceous and mostly dull greenish entire leaves; parasitic on trees. The floral envelopes are various. In Mistletoe (which is diœcious) the anthers are sessile and adnate to the face of the sepals, one to each; while Loranthus has both calyx and corolla, the latter most conspicuous, and a stamen before each petal and adnate to it. The ovary is one-celled, with a single suspended ovule, consisting of a nucleus without integuments. Fruit a one-seeded berry. Embryo small, in fleshy albumen. — *Ex.* Loranthus; Viscum, the Mistletoe, from the glutinous berries of which *birdlime* is made; Phoradendron, the American Mistletoe. The bark is astringent.

904. Ord. Piperaceæ (*Pepper Family*). A peculiar order of tropical herbaceous or shrubby plants, with jointed stems, naked (achlamydeous) but perfect flowers in spikes or spicate racemes, a one-celled ovary with an erect orthotropous ovule; the embryo minute in a *vitellus* or persistent embryo-sac at the apex of the albumen. — Pungent and stimulant properties characterize the order. Piper nigrum furnishes *Black pepper*, and *White pepper* is the same, with the flesh of the drupe removed. The fruit of Cubeba officinalis, &c. furnishes *Cubebs*, which are hot aromatics, acting also on the mucous membranes. The pungency in all these plants is owing to a peculiar volatile oil and resin. They also yield a crystalline matter, called *Piperine*. Others have more intoxicating properties, as *Betel*, the leaves of a Chavica, chewed by the Malays, and the *Ava* (Macropiper methysticum) from which the South-Sea Islanders make their inebriating drink.

905. Ord. Saururaceæ (*Lizard's-tail Family*); differs from the Pepper Family (of which it is an offshoot) in the feebly pungent qualities, the distinct stipules (when these are evident), and the three or

more ovaries, separate or somewhat united, with one or more ovules in each. — *Ex.* *Saururus*, *Hottuynia* : a small group.



906. *Ord. Ceratophyllaceæ* (*Hornwort Family*) consists of the single genus *Ceratophyllum* (growing in ponds and streams in many parts of the world); distinguished by the whorled and dissected leaves with filiform segments; the flowers monœcious and sessile in the axil of the leaves; the stamens indefinite, with sessile anthers; and the simple one-celled ovary, which forms a beaked achenium in fruit, containing an orthotropous suspended seed, with four cotyledons! and a manifest plumule.

907. *Ord. Callitricheacæ* (*Water-Starwort Family*), formed of the genus *Callitriche*; aquatic annuals, with opposite entire leaves; the axillary flowers (either perfect or monœcious) with a two-leaved

FIG. 1127. *Saururus cernuus*. 1128. A separate flower, with its bract and a part of the axis magnified. 1129. A more magnified anther, discharging its pollen from one cell. 1130. Cross-section of the ovary. 1131. Vertical section of one of the carpels in fruit, and of the contained seed, with the sac at the extremity of the albumen, containing the minute embryo. 1132. A seed. 1133. Same, with the outer integument (testa) removed, showing the minute embryo. 1134. The latter, highly magnified. 1135. Section of the same, showing the enclosed heart-shaped embryo.

involucre, but entirely destitute of calyx and corolla; stamen one (or rarely two), hypogynous, with a slender filament, and a reniform confluent one-celled anther; the ovary four-lobed, four-celled, indehiscent in fruit; the seeds albuminous.



908. Ord. Podostemaceæ (*River-weed Family*) comprises a few (chiefly American and Asiatic) aquatics, in rivers, with the aspect of Mosses, Hepaticæ, &c.; their small flowers arising from a spathe; the calyx often entirely wanting; the stamens frequently unilateral and monadelphous; the ovary two- or three-celled, with distinct styles; in fruit forming a ribbed capsule, containing numerous ex-albuminous seeds attached to a central column. — *Ex.* Podostemon.

909. Ord. Euphorbiaceæ (*Spurge Family*). Herbs, shrubs, or trees, often with a milky juice: in northern temperate climes chiefly represented by the genus *Euphorbia*; which is remarkable for having numerous staminate flowers, reduced to a single stamen (487), enclosed in an involucre along with one pistillate flower, this reduced to a compound pistil, and also achlamydeous, or with an obsolete calyx. But other genera have a regular calyx both to the staminate and pistillate flowers; and a few are likewise provided with petals. Ovary of two to nine more or less united carpels, coherent to a central prolongation of the axis: styles distinct, often two-cleft. Fruit mostly capsular, separating into its elementary carpels, or cocci (usually leaving a persistent axis): these commonly open elastically

FIG. 1136. *Callitriche verna*, about the natural size. 1137. Perfect flowers, magnified. 1138. A staminate and pistillate flower, magnified. 1139. The fruit. 1140. Cross-section of the fruit. 1141. Vertical section through the pericarp, seeds, and embryo.

by one or both sutures. Seed with a large embryo in fleshy albumen, suspended. — *Ex.* Euphorbia (Spurge), Croton, Buxus (the Box). Acrid and deleterious qualities pervade this large order,



chiefly resident in the milky juice. But the starchy accumulations in the rhizoma, or underground portion of the stem, as in the *Mandioc* or *Cassava* (*Janipha Manihot*) of tropical America, are perfectly innocuous, when freed from the poisonous juice by washing and heating. The starch thus obtained is the *Cassava*, which, when granulated, forms the *Tapioca* of commerce. The farinaceous albumen of the seed is also innocent, and the fixed oil which it frequently contains is perfectly bland. But the oil procured by expression abounds in the juices of the embryo and integuments of the seed, and possesses more or less active properties. The seeds of *Ricinus communis* yield the *Castor oil*; and those of *Croton Tiglium*, and some other Indian species, yield the violently drastic *Croton oil* or *Oil of*

FIG. 1142. Flowering branch of *Euphorbia corollata*; the lobes of the involucre resembling a corolla. 1143. Vertical section of an involucre (somewhat enlarged), showing a portion of the staminate flowers surrounding the pistillate flower (a), which in fruit is raised on a slender pedicel. 1144. One of the staminate flowers enlarged, with its bract, a: b, the pedicel, to which the single stamen, c, is attached by a joint; there being no trace of floral envelopes. 1145. Cross-section of the 3-pistillate fruit. 1146. Vertical section of one of the pistils in fruit (the two others having fallen away from the axis), and of the contained seed; showing the embryo lengthwise. 1147. A seed.

Tigilum. Some plants of the family are most virulent poisons; as, for example, the Manchineal-tree of the West Indies (*Hippomane Manicella*), which is said even to destroy persons who sleep under its shade; and a drop of the juice blisters the hand. The hairs of some species (such as our *Cnidioscolus stimulosus*) sting like Nettles. Box-wood is invaluable to the wood-engraver. The purple dye, called *Turnsole* is from *Crozophora tinctoria*. Another most important product of this order is *Caoutchouc*, which is yielded by various plants of different families; but the principal supply of the article (that of Para, Demarara, and Surinam) is furnished by species of *Siphonia*.

910. Ord. *Empetraceæ* (*Crowberry Family*). Low, shrubby evergreens, with the aspect of Heaths; the leaves crowded and acerose,



with small (diœcious or polygamous) flowers produced in the axils. Calyx consisting of regular imbricated sepals, or represented by imbricated bracts. Stamens few: pollen of four grains coherent in one, as in Heath. Ovary three- to nine-celled, with a single erect ovule in each cell: style short or none: stigmas lobed and often laciniated. Fruit a drupe, with from three to nine bony nucules. Seeds albuminous; the radicle inferior. — *Ex.* *Empetrum*, *Ceratiola*, *Corema*; unimportant plants. Probably no more than apetalous *Ericaceæ*; but the stigmas are peculiar.

911. Ord. *Urticaceæ* (*Nettle Family*), shrubs, or herbs, with stipules, often with milky juice, and diclinous or polygamous, rarely perfect flowers, furnished with a regular calyx; which is free from the one-

FIG. 1148. Branch of *Ceratiola ericoides* in fruit. 1149. Magnified staminate flower, with its bracts. 1150. The two stamens, with an inner bract or sepal. 1151. Magnified pistillate flower, with its imbricated bracts. 1152. The pistil separate; one of the cells laid open by a vertical section, showing the erect ovule. 1153. Drupe, with the persistent scales at the base. 1154. Transverse section of its endocarp, or two nucules, with the enclosed seed and embryo. 1155. Vertical section of the seed.

celled (sometimes two-celled) ovary and the always one-celled and one-seeded fruit, but sometimes enclosing it. Stamens as many as the lobes of the calyx and opposite them, or sometimes fewer. Embryo large; cotyledons mostly broad; the radicle superior in the fruit. Stipules often deciduous. A large and greatly diversified order, comprising at least four well-marked suborders.

912. Subord. *Ulmaceæ* (*Elm Family*). Trees or shrubs, with a watery juice, alternate rough leaves, perfect or merely polygamous flowers, two styles or stigmas; the ovary either one- or two-celled, with one ovule suspended from the summit of each. Fruit either a samara (Fig. 578), with a straight embryo and no albumen, as in



the Elm (*Ulmus*); or a drupe with a curved embryo and scanty albumen, as in *Celtis* (Hackberry), the type of the tribe *CELTIDEÆ*. Timber-trees. The inner bark of the Slippery Elm is highly charged with mucilage. Hackberries are edible.

913. Subord. *Artocarpææ* (*Bread-fruit Family*); which are chiefly tropical trees or shrubs with a milky or yellow juice; the monœcious or diœcious flowers mostly aggregated into fleshy heads, and

FIG. 1156. Flower of the Slippery Elm. 1157. Calyx laid open and the ovary divided vertically. 1158. Fruit, the cell laid open to show the single seed. 1159. The latter magnified. 1160. Its embryo.

FIG. 1161. Branch of *Celtis Americana*, in flower. 1162. Enlarged flower, divided vertically. 1163. Drupe, the flesh divided to show the stone. 1163'. The coiled embryo.

forming a multiple fruit, or else enclosed in a dry or succulent involucre. Styles or stigmas commonly two. Ovary ripening into an achenium. Seeds with or without albumen. — *Ex.* Artocarpus (the Bread-fruit), Morus (the Mulberry, Fig. 593–595), Maclura (the Osage Orange), Ficus (the Fig, Fig. 590–592). The fruit is often innocent and edible, at least when cooked; while the milky juice is more or less acrid or deleterious. It also abounds in *Caoutchouc*; much of which is obtained from some South American trees of this order, and from *Fiscus elastica* in Java. In one instance, however, the milky juice is perfectly innocent; that of the famous Cow-tree of South America, which yields a rich and wholesome milk. One of the most virulent of poisons, the *Bohon Upas*, is the concrete juice of *Antiaris toxicaria* of the Indian Archipelago. The Bread-fruit is the fleshy receptacle and multiple fruit of Artocarpus. *Fustic* is the wood of the South American Maclura tinctoria; the wood of our own Maclura or Osage Orange is used by the Western Indians for bows. The resin called *Gum Lac* exudes and forms small grains on the branches of the celebrated Banyan-tree (*Ficus Indica*, Fig. 142).

914. Subord. Urticæ (*True Nettle Family*); which are herbs in colder countries, but often shrubs or trees in the tropics, with a watery juice, often with stinging hairs; the monœcious or diœcious flowers mostly loose, spicate, or paniced. Ovule orthotropous. Ovary always one-celled, and style or stigma one; the achenium usually surrounded by a dry and membranous calyx. Embryo straight, in fleshy albumen. — *Ex.* Urtica (the Nettle), &c. Innocuous plants, except for the stinging hairs of many species. The inner bark of Nettles yields very tough and slender fibres.

915. Subord. Cannabinæ (*Hemp Family*). Annual erect herbs, or perennial twining plants, with a watery juice and diœcious flowers; the staminate flowers racemose or paniced; the pistillate glomerate, or imbricated with bracts, and forming a kind of strobile-like ament; their calyx one-leaved. Stigmas two. Ovary one-celled, with an erect orthotropous ovule. Embryo coiled or bent: albumen none. — *Ex.* Cannabis (the Hemp), Humulus (the Hop). *Hops* are the catkins with large bracts; the bitter and sedative principle chiefly resides in the yellow grains that cohere to the scales and cover the fruit. The leaves of Hemp, when grown in a hot climate, are powerfully stimulant and narcotic, and are used in the East for intoxication. The inner bark is used for cordage, &c.

916. Ord. *Platanaceæ* (*Plane-tree Family*) consists of the single genus *Platanus* (*Plane-tree*, *Button-ball*), with one Asiatic and one or more North-American species: fine trees, with a watery juice, and alternate palmately-lobed leaves, with sheathing stipules. Flowers in globose amentaceous heads; both kinds destitute of floral envelopes. Fruit a one-seeded club-shaped little nut, the base furnished with bristly hairs. Seed albuminous.

917. Ord. *Juglandaceæ* (*Walnut Family*). Trees, with alternate pinnated leaves, and no stipules. Flowers monœcious. Sterile flowers in aments, with a membranous irregular calyx, and indefinite stamens. Fertile flowers few, clustered, with the calyx adherent to the incompletely two- to four-celled but one-ovuled ovary, the limb small, three- to five-parted; sometimes with as many small petals. Ovule orthotropous. Fruit drupaceous; the exocarp fibrous-fleshy and coherent, or else coriaceous and dehiscent: endocarp bony. Seed four-lobed, without albumen. Embryo oily: cotyledons corrugate, two-cleft. — *Ex.* *Juglans* (*Walnut*, *Butternut*), *Carya* (*Hickory*, *Pecan*, &c.). — The greater part of the order is North American. The timber is valuable; especially that of Black Walnut, for cabinet-work, and that of Hickory, for its great elasticity and strength. The young fruit is acrid: the seeds of several are delicious; those of the Walnut abound in a drying oil.

918. Ord. *Cupuliferæ* (*Oak Family*). Trees or shrubs, with alternate and simple straight-veined leaves, and deciduous stipules. Flowers usually monœcious. Sterile flowers in aments, with a scale-like or regular calyx, and the stamens one to three times the number of its lobes. Fertile flowers solitary, two to three together, or in clusters, furnished with an involucre which encloses the fruit or forms a cupule at its base. Ovary adnate to the calyx, and crowned by its minute or obsolete limb, two- to six-celled with one or two pendulous ovules in each cell: but the fruit is a one-celled and one-seeded nut (Fig. 576). Seed without albumen. Embryo with thick and fleshy cotyledons, which are sometimes coalescent. — *Ex.* *Quercus* (the *Oak*), *Fagus* (the *Beech*), *Corylus* (the *Hazel-nut*), *Castanea* (the *Chestnut*), &c. Some of the principal forest-trees in northern temperate regions. The valuable timber and edible nuts they furnish are too well known to need enumeration. The astringent bark and leaves of the Oak abound in tannin, gallic acid, and a bitter extractive called *Quercine*; they are used in tanning and dyeing. *Quercitron* is obtained from the *Quercus tinc-*

toria. *Galls* are swellings on the leafstalks, &c., when wounded by certain insects; those of commerce are derived from *Q. infectoria* of Asia Minor. *Cork* is the exterior corky layer of the bark of the Spanish *Quercus Suber*.



919. Ord. *Myricaceæ* (*Sweet-Gale Family*). Shrubs, with alternate and simple aromatic resinous-dotted leaves, monœcious or dioecious. Differs from the next principally by the one-celled ovary, with a single erect orthotropous ovule, and a drupe-like nut. — *Ex.* *Myrica*, *Comptonia*, the Sweet Fern. The drupes of *M. cerifera* (our Candleberry or Bayberry) yield a natural wax.

920. Ord. *Betulaceæ* (*Birch Family*). Trees or shrubs, with alternate and simple straight-veined leaves, and deciduous stipules. Flowers monœcious; those of both kinds in aments (Fig. 312), and commonly achlamydeous, placed three together in the axil of each three-lobed bract. Stamens definite. Ovary two-celled, each cell with one suspended ovule: styles or stigmas distinct. Fruit membranaceous or samara-like, one-celled and one-seeded, forming with the three-lobed bracts a kind of strobile. Albumen none. — *Ex.* *Betula* (the Birch), *Alnus* (Alder). The bark is sometimes astrin-

FIG. 1164. *Quercus Chinquapin* in fruit: *a*, cluster of sterile aments. 1165. A magnified staminate flower. 1166. Transverse section of an ovary, showing the three cells with two ovules in each. 1167. The immature seed, with the accompanying abortive ovule. 1168. The nut (acorn), in its scaly involucre, or cupule. 1169. Vertical section of the same, and of the included seed and embryo, showing the thick cotyledons.

gent, and that of the Birch is aromatic. The peculiar odor of Russia leather is said to be owing to a pyroligneous oil obtained from *Betula alba*, or White Birch.



921. Ord. Salicaceæ (*Willow Family*). Trees or shrubs, with alternate simple leaves, furnished with stipules. Flowers dioecious; both kinds in aments, and destitute of floral envelopes (achlamydeous), one under each bract. Stamens two to several, sometimes monadelphous. Ovary one-celled, many-ovuled! Styles or stigmas two, often two-cleft. Fruit a kind of follicle opening by two valves. Seeds numerous, ascending, furnished with a silky coma! Albumen none. — *Ex.* *Salix* (Willow, Fig. 415 – 419), and *Populus* (the Poplar). Trees with light and soft wood: the slender, flexible shoots of several Willows are employed for wicker-work. The bark is bitter and tonic, and contains a peculiar substance (*Salicine*), which possesses febrifugal qualities. The buds of several Poplars exude a fragrant balsamic resin.

FIG. 1170. Young ament of staminate flowers of a Birch (*Betula fruticosa*?). 1171. One of the three-lobed scales of the same, enlarged, showing the flowers (stamens) on the inner side. 1172. Ament of pistillate flowers. 1173. Branch in fruit. 1173'. One of the scales with its three flowers (pistils) seen from within. 1174. Magnified section of one of the two-celled pistils, displaying the ovule suspended from the summit of each cell. 1175. The pistils (with their subtending bract) in a more advanced state. 1176. Magnified cross-section of one of the ovaries. 1177. The mature fruit, with the cell divided vertically; the single seed occupying the cavity; a mere trace of the other cell being visible. 1178. The seed removed. 1179. The embryo.

Subclass 2. GYMNASPERMOUS EXOGENOUS PLANTS.

Ovules, and consequently the seeds, naked, that is, not enclosed in an ovary (560); the carpel being represented either by an open scale, as in Pines; or by a more evident leaf, as in *Cycas*; or else wanting altogether, as in the Yew.

922. Ord. Coniferæ (*Pine Family*). Trees or shrubs, with branching trunks, abounding in resinous juice (the wood chiefly consisting of a tissue somewhat intermediate between ordinary woody fibre and vessels, and marked with circular disks); the leaves mostly



evergreen, scattered or fascicled, usually rigid and needle-shaped or

FIG. 1180. Carpellary scale of *Cupressus sempervirens* (the true Cypress), seen from within, and showing the numerous orthotropous ovules that stand on its base. 1181. Branch of *Abies Canadensis* (Hemlock Spruce) with lateral staminate flowers, and a fertile strobile. 1182. Staminate ament, magnified. 1183. Carpellary scale of a fertile ament, with its bract. 1184. Similar fertile scale, more magnified and seen from within; showing the two ovules adherent to its base: one of them (the left) laid open. 1185. The scale in front, nearly of the natural size, its inner surface occupied by the two seeds. 1186. Polycotyledonous embryos of *Abies* and *Cypress*. 1187. Vertical section of an embryo. 1188. Strobile of *Taxodium distichum* (Suborder Cupressineæ).

linear, entire. Flowers monœcious or diœcious, commonly amentaceous. Staminate flowers consisting of one or more (often monadelphous) stamens, destitute of calyx or corolla, arranged on a common rhachis so as to form a kind of loose ament. — The particular structure of the flowers and fruit varies in the subordinate groups, chiefly as follows:—

923. Subord. *Abietinæ* (*Fir, or Pine Family proper*). Fertile aments formed of imbricated scales; which are the flat and open carpels, and bear a pair of ovules adherent to their base, with the foramen turned downwards (Fig. 511). Scales subtended by bracts. Fruit a strobile or cone (Fig. 596). Integument of the seed coriaceous or woody, more or less firmly adherent to the scale. Embryo in the axis of fleshy albumen, with two to fifteen cotyledons. Buds scaly.

924. Subord. *Cupressinæ* (*Cypress Family*). Fertile aments of few scales crowded on a short axis, or more numerous and peltate, not bracteate. Ovules one, two, or several, borne on the base of the scale, erect (the foramen looking towards its apex, Fig. 516, 1180). Fruit an indurated strobile, or sometimes fleshy and with the scales concreted, forming a kind of drupe. Integument of the seed membranous or bony. Cotyledons two or more. Anthers of several parallel cells, placed under a shield-like connective. Buds naked. — *Ex.* *Cupressus* (Cypress), *Taxodium* (American Cypress), *Juniperus* (Juniper, Red Cedar).

925. Subord. *Taxinæ* (*Yew Family*). Fertile flowers solitary, terminal, consisting merely of an ovule, forming a drupaceous or nut-like seed at maturity. There are, therefore, no strobiles and no carpellary scales. Embryo with two cotyledons. Buds scaly. — *Ex.* *Taxus* (the Yew), *Torreya*.

926. It is unnecessary to specify the important uses of this large and characteristic family, which comprises the most important timber-trees of cold countries, and also furnishes resinous products of great importance, such as *turpentine, resin, pitch, tar, Canada balsam, &c.* The terebinthine *Juniper-berries* are the fruit of *Juniperus communis*. The Larch yields *Venetian turpentine*. The powerful and rubefacient *Oil of Savin* is derived from *J. Sabina* of Europe: for which our nearly allied *J. Virginiana* (Red Cedar) may be substituted. The leaves of the Yew are narcotic and deleterious. The bark of Larch, and especially of the Hemlock-Spruce, is used for tanning.

927. Ord. Cycadaceæ (*Cycas Family*). Tropical plants, with an unbranched cylindrical trunk, increasing, like Palms, by a single terminal bud; the leaves pinnate and their segments more or less rolled up from the apex (circinate) in veneration, in the manner of Ferns. Flowers diœcious; the staminate in a strobile or cone; the pistillate also in strobiles, or else (in *Cycas*) occupying contracted



and partly metamorphosed leaves; the naked ovules borne on its margins. — *Ex.* *Cycas*, *Zamia*. — A kind of *Arrowroot* is obtained from these thickened stems, or caudexes, as from our dwarf Florida species (the *Coontie* of the aborigines); and a coarse *Sago* from the trunk of *Cycas*.

FIG. 1189. *Zamia integrifolia* (the *Coontie* of Florida). 1190. Section of the sterile ament. 1191. One of its scales detached, bearing scattered anthers. 1192. Fertile ament, from which a quarter-section is removed. 1193. A pistillate flower, consisting of two ovules pendent from the thickened summit of the carpellary scale. 1194. A drupaceous seed, from which a part of the pulpy outer portion, at the apex, is removed. 1195. Vertical section through the seed (of the natural size), showing the pulpy outer coat, the hard inner integument, the albumen, and the embryo.

Class II. ENDOGENOUS OR MONOCOTYLEDONOUS PLANTS.

Stem not distinguishable into bark, pith, and wood ; but the latter consisting of bundles of fibres and vessels irregularly imbedded in cellular tissue ; the rind firmly adherent ; no medullary rays, and no appearance of concentric layers : increase in diameter effected by the deposition of new fibrous bundles, which at their commencement occupy the central part of the stem. Leaves seldom falling off by an articulation, sheathing at the base, usually alternate, entire, and with simple parallel veins (nerved). Floral envelopes when present mostly in threes, never in fives ; the calyx and corolla most commonly undistinguishable in texture and appearance. Embryo with a single cotyledon ; or, if the second is present, it is much smaller than the other, and alternate with it.

CONSPECTUS OF THE ORDERS.

Group 1. Flowers on a spadix, furnished with a double and free perianth (answering to calyx and corolla). Ovary one- to three-celled, with a single ovule in each cell. Embryo in hard albumen.—Trees with unbranched columnar trunks. PALMÆ.

Group 2. Flowers on a spadix ; with the perianth simple and free, or reduced to a few scales, or commonly altogether wanting. — Chiefly herbs.

Terrestrial. Fruit nut-like, or comose, one-seeded. TYPHACEÆ.
Terrestrial, mostly with a spathe. Fruit baccate. ARACEÆ.

Aquatic (floating or immersed).
Flowers developed from the edge of the floating frond. LEMNACEÆ.
Flowers axillary or on a spadix. NAIADACEÆ.

Group 3. Flowers not spadiceous, furnished with a double and free perianth (calyx and corolla). Ovaries several, distinct, or sometimes united. Aquatic herbs. ALISMACEÆ.

Group 4. Flowers with a simple or double perianth, which is adherent to the ovary, regular, developed from a spathe, polygamous or diclinous. Ovary one-celled with parietal placentæ, or 3-9-celled. Seeds destitute of albumen.—Aquatics. HYDROCHARIDACEÆ.

Group 5. Flowers perfect with the double or 6-merous perianth adherent to the ovary (or more or less free in some Hæmodoracæ and Bromeliacæ). Seeds with albumen, except perhaps the very minute ones of Orchidacæ, &c. Leaves parallel-veined.

- Stamens gynandrous, 1 or 2 fertile. Flower irregular. ORCHIDACEÆ.
- Stamens not gynandrous. Flower irregular.
- Fertile stamen 1, inferior. ZINGIBERACEÆ.
- Fertile stamen 1, superior. CANNACEÆ.
- Fertile stamens mostly 5, the sixth abortive. MUSACEÆ.
- Stamens not gynandrous, regularly 3 or 6.
- Anthers extrorse. Stamens 3, before the sepals. IRIDACEÆ.
- Anthers introrse, when 3 before the inner perianth.
- Anther-cells separated by a broad connective. BURMANNIACEÆ.
- Anther-cells approximate or joined.
- Leaves not scurfy. Stems from bulbs. AMARYLLIDACEÆ.
- Leaves scurfy or woolly. No bulbs.
- Terrestrial. Stamens 3 or 6. HEMODORACEÆ.
- Mostly epiphytes. Stamens 6. BROMELIACEÆ.
- Group 6.* Flowers diœcious, with a 6-merous perianth adherent to the ovary.
- Seeds with a minute embryo in hard albumen. Leaves ribbed and netted-veined, articulated with the stem. DIOSCOREACEÆ.
- Group 7.* Flowers diœcious or perfect; the regular perianth free from the ovary.
- Styles or sessile stigmas distinct. Embryo minute in hard albumen.
- Leaves more or less netted-veined. SMILACEÆ.
- Group 8.* Flowers perfect, not from a spathe, with the regular 6-merous perianth free from the ovary. Seeds anatropous, with albumen.
- Perianth not glumaceous. Leaves parallel-veined.
- Anthers introrse. Styles united into one. LILIACEÆ.
- Anthers extrorse. Styles mostly separate. MELANTHACEÆ.
- Perianth glumaceous. Styles united into one. JUNCACEÆ.
- Group 9.* Flowers perfect, developed from a spathe, commonly somewhat irregular, the 6-merous perianth free from the ovary. Seeds anatropous, with albumen. Aquatics. PONTEDERIACEÆ.
- Group 10.* Flowers with a double or imbricated perianth, free from the ovary; the exterior divisions (sepals) herbaceous or glumaceous; the inner (petals) petaloid, free from the one- to three-celled ovary. Seeds 2, 3, or many, orthotropous; the embryo at the extremity of the albumen farthest from the hilum.
- Flowers perfect. Sepals herbaceous. Petals colored. COMMELYNACEÆ.
- Flowers perfect, capitate. Sepals and bracts glumaceous. XYRIDACEÆ.
- Flowers monœcious or diœcious, capitate. ERIOCAULONACEÆ.
- Group 11.* Flowers imbricated with glumaceous bracts (glumes), and disposed in spikelets; the proper perianth none or rudimentary. Ovary one-celled, one-ovuled. Seeds anatropous. Embryo at the extremity of the albumen next the hilum.
- Sheaths of the leaves closed. Glume or bract single. CYPERACEÆ.
- Sheaths open. Glumes mostly in pairs. GRAMINEÆ.

928. Ord. *Palmae* (*Palms*). Chiefly trees, with unbranched cylindrical trunks growing by a terminal bud. Leaves large, clustered, fan-shaped or pinnated, plaited in veneration. Flowers small, perfect or polygamous, mostly with a double (6-merous) perianth; the stamens usually as many as the petals and sepals together. Ovary 1-3-celled, with a single ovule in each cell. Fruit a drupe or berry. Seeds with a cartilaginous albumen, often hollow; the embryo placed in a small separate cavity. — *Ex.* Palms, the most majestic race of plants within the tropics, and of the highest value to mankind, are scarcely found beyond the limits of these favored regions. The Date-tree (*Phoenix dactylifera*, the leaves of which are the *Palms* of Scripture), a native of Northern Africa, endures the climate of the opposite shores of the Mediterranean: while in the New World, *Chamærops Palmetto* (Fig. 184), the only arborescent species of the United States, and one or two low Palms with a creeping caudex (*Dwarf Palmetto*), extend from Florida to North Carolina. Palms afford food and raiment, wine, oil, wax, flour, sugar, salt, thread, weapons, utensils, and habitations. The *Cocconut* (*Cocos nucifera*) is perhaps the most important, as well as the most widely diffused species. Besides its well-known fruit, and the beverage it contains,



the hard trunks are employed in the construction of huts; the terminal bud (as in our Palmetto and other Cabbage Palms) is a delicious article of food; the leaves are used for thatching, for making

FIG. 1196. Branch of the inflorescence of *Chamærops hystrix* (Blue Palmetto). 1197. A sterile flower. 1198. Perfect flower, with the calyx and corolla removed. 1199. Same, with three of the stamens removed, so as more distinctly to show the three somewhat united carpels. 1200. One of the carpels enlarged, seen laterally. 1201. Same, with a section of its inner face, showing the ovule or young seed. 1202. Vertical section of a young coconut, showing the hollow albumen; and also the small embryo in a separate little cavity. 1203. Section of a Palm-stem.

hats, baskets, mats, fences, for torches, and for writing upon; the stalk and midrib for oars; their ashes yield abundance of potash; the juice of the flowers and stems (replete with sugar, which is sometimes separated under the name of *Jagery*) is fermented into a kind of wine, or distilled into *Arrack*; from its spathes (as from some other Palms), when wounded, flows a grateful laxative beverage, known in India by the name of *Toddy*; the rind of the fruit is used for culinary vessels; its tough, fibrous, outer portion is made into very strong cordage (*Coir rope*); and an excellent fixed oil is copiously expressed from the kernel. *Sago* is procured from the trunks of many Palms, but chiefly from species of *Sagus* of Eastern India. *Canes* and *Rattans* are the slender, often prostrate, stems of species of *Calamus*. — The *Phytelephas*, or so-called Ivory Palm, of Central America, the seeds of which are the *Vegetable Ivory* now so commonly used by the turner, in place of ivory, for small articles, is not a genuine Palm, having polygamo-dioecious flowers with a rudimentary perianth, or none at all, &c. It is proposed as the type of an order (*PHYTELEPHANTÆ*); but may for the present be appended to the Palms; between which and the succeeding orders stands the

929. *Ord. Pandanaceæ*; tropical arborescent plants, of Palm-like port, but their simplified diclinous flowers destitute of a perianth, the one-celled ovary many-ovuled. The seeds of *Pandanus* (the Screw-Pine, Fig. 140), &c. are eatable. From the young leaves of *Carludovica* the famous Panama hats are braided.

930. *Ord. Typhaceæ* (*the Cat-tail Family*) consists of two genera; namely, *Typha* (the Cat-tail), and *Sparganium* (Bur-reed), of no important use. They are spadiceous plants with excessively reduced flowers, having no perianth.

931. *Ord. Araceæ* (*Arum Family*). Herbs, with a fleshy corm or rhizoma, often shrubby or climbing plants in the tropics; the leaves sometimes compound or divided, commonly netted-veined. Flowers mostly on a spadix (often naked at the extremity), usually surrounded by a spathe or hood (Fig. 313, 314). Flowers commonly monœcious, and destitute of envelopes, or with a single perianth. Ovary one- to several-celled, with one or more ovules. Fruit a berry. Seeds with or without albumen. — *Ex.* *Arum*, *Calla*, *Symplocarpus* (Skunk-Cabbage), *Orontium*, *Acorus* (Sweet Flag): the three latter bear flowers furnished with a perianth. — All are endowed with an acrid volatile principle, which is merely pungent and aromatic in

Sweet Flag (*Acorus Calamus*), but extremely sharp in Arum, Indian Turnip, &c. The acrid principle of these plants is volatile, and is dissipated by heat or in drying. When cooked, their farinaceous corms are eatable. That of *Taro* of the South Sea Islands, and some other species of *Colocasia*, are important articles of food. *Symplocarpus fetida* exhales a strong odor, very like that of the



skunk, whence, as it has large and roundish leaves in a radical cluster, it is called Skunk Cabbage. The roots have been used in medicine as an antispasmodic.

932. Ord. Lemnaceæ (*Duckweed Family*), consisting chiefly of *Lemna* (Duckweed or Water Flax-seed); floating plants, with their roots (if any) arising from the bottom of a flat frond, and hanging loose in the water; their flowers produced from the margin of the frond, bursting through a membranous spathe; the sterile, of one or

FIG. 1204. Young leaf, and 1205, spathes and flowers, of *Symplocarpus fetida*. 1206. A separate flower when young. 1207. A detached sepal and stamen seen from within. 1208. An anther seen from the front. 1209. The spadix or collective head in fruit; a quarter-section removed, showing sections of the immersed seeds. 1210. A seed detached, of the natural size. 1211. Section of the seed, with its large globular embryo and plumule; in this plant there is no albumen.

two stamens; the fertile, of a one-celled ovary; in fruit a utricle: they are a kind of minute and greatly reduced Araceæ, connecting that order with the next.



933. Ord. Naiadaceæ (*Pondweed Family*). Water-plants, with cellular leaves, and sheathing stipules or bases: the flowers inconspicuous, sometimes perfect. Perianth simple and scale-like, or none. Stamens definite. Ovaries solitary, or two to four and distinct, one-seeded. Albumen none. Embryo straight or curved.—*Ex.* Potamogeton (Pondweed), Najas, Ruppia, Zostera; the two latter in salt or brackish water.

934. Ord. Alismaceæ (*Water-Plantain Family*). Marsh herbs, with the leaves and scapes usually arising from a creeping rhizoma; the former either linear, or bearing a flat limb, which is ribbed or nerved, but the veinlets commonly reticulated. Flowers regular, perfect or polygamous, mostly in racemes or panicles, not on a spadix. Perianth double, the three petals commonly different from the sepals, so as evidently to represent a calyx and a corolla. Seeds solitary in each carpel or cell, straight or curved, destitute of albumen.—*Ex.* Alisma (Water-Plantain), Sagittaria (Arrowhead); belonging to the proper Alisma Family, which has the seed (and conse-

FIG. 1212. Whole plant of *Lemna minor*, magnified, bearing a staminate monandrous flower. 1213. An individual with a diandrous perfect flower; which at 1214 is seen separate, with its spathe, highly magnified. 1215. Flower of *Lemna gibba*, much magnified. 1216. Vertical highly magnified section of the pistil and the contained ovule of *Lemna minor*. 1217. The fruit, and 1218, its section, showing the seed. 1219. Section through the highly magnified seed and large embryo.

quently the embryo) curved or doubled upon itself. Triglochin and Scheuchzeria chiefly constitute the suborder JUNCAGINÆ; where the seed and embryo are straight, and the petals (if present) are greenish like the calyx. Slightly acrid plants, and some of them astringent.



935. Ord. Butomaceæ, represented by Butomus, the Flowering-Rush of Europe, and three small tropical genera, is a form of the last with many ovules attached to the whole face of the carpels: these are separate or combined. Some have a milky juice.

936. Ord. Hydrocharidaceæ (*Frog's-bit Family*) consists of a few aquatic herbs, with diœcious or polygamous regular flowers on scape-like peduncles from a spathe, and simple or double floral envelopes, which in the fertile flowers are united in a tube, and adnate to the 1-6-celled ovary, more commonly one-celled with three parietal placentæ. Seeds numerous, without albumen. — *Ex.* Limnobium, Vallisneria, Anacharis.

937. Ord. Orchidaceæ (*Orchis Family*). Herbs, of varied aspect and form; distinguished from the other orders with an adnate ovary and from all other plants, by their irregular flowers, with a perianth

FIG. 1220. Raceme or spike of Triglochin palustre. 1221. Enlarged flower. 1222. Enlarged flower, showing the ovary and stamen. 1223. The club-shaped capsule. 1224. A magnified seed, exhibiting the embryo and chalazæ. 1225. Embryo of the same. 1226. Vertical section of the same embryo, showing the plumule to view. 1227. Cross-section (more magnified), showing the plumule and the cotyledons around the plumule.

FIG. 1228. Leaf, and 1229, flower, of Alisma Plantago. 1230. Mo. the petals removed. 1231. Carpel, with the ovary divided, showing the ovules. 1232. Vertical section of the germinating seed of Alisma Damasonium; a, the plumule; b, the cotyledon; c, the protruding radicle.

of six parts; their single fertile stamen (or in *Cypripedium* their two stamens) coherent with the style (composing the *column*); their pollen usually combined into two or more granular or waxy masses (*pollinia*); the ovary one-celled, with three parietal placentæ,



covered with numerous minute seeds. — *Ex.* Orchis, *Cypripedium* (Ladies' Slipper), *Arethusa*, &c. In the tropics many are Epiphytes (149, Fig. 144). Many are cultivated for their beauty and singularity. The tuberiferous roots are often filled with a very dense mucilaginous or glutinous substance (as those of our *Aplectrum*, thence called Putty-root). Of this nature is the *Salep* of commerce, the produce of some unascertained species of Middle Asia. The fragrant *Vanilla* is the fleshy fruit of *Vanilla planifolia* and other tropical American species. The roots of *Cypripedium* are used as a substitute for Valerian.

938. Ord. Zingiberaceæ (*Ginger Family*) consists of some mostly showy tropical aromatic herbs, the nerves of their leaves diverging

FIG. 1233. *Orchis spectabilis*: *a*, a separate flower. 1234. Column (somewhat magnified), from which the other parts are cut away: the two anther-cells opening and showing the pollen-masses. 1235. Magnified pollen-mass, with its stalk. 1236. *Arethusa bulbosa*. 1237. The column, enlarged: the anther terminal and opening by a lid. 1238. Magnified anther, with the lid removed, showing the two pollen-masses in each cell.

from a midrib; the adnate perianth irregular and triple (having a corolla of two series as well as a calyx); fertile stamen one, on the anterior side of the flower, free; the fruit a three-celled capsule or berry; the seeds several: with the embryo in a little sac at one extremity of the farinaceous albumen. — There are, in fact, six stamens in the andrœcium, the three exterior petaloid and forming the so-called inner corolla, and two of the inner verticel are sterile. — Their properties and economical uses are well represented by the pungent aromatic rootstock of *Ginger* (*Zingiber officinale*), *Galin-gale* (*Alpinia Galanga*, &c.), the seeds of *Cardamon*, &c. The same cordial qualities in lesser degree exist in the roots of *Curcuma longa*, &c. which furnish the coloring matter called *Turmeric*; while other species yield starch, like the closely allied

939. Ord. Cannaceæ (*Arrowroot Family*), which also consists of tropical plants, differs from the preceding chiefly in the want of aroma, and in having the single fertile stamen posterior, with a one-celled anther. — *Ex.* *Maranta arundinacea*, which yields the *Arrowroot* of the West Indies; the tubers of which are filled with starch.

940. Ord. Musaceæ (*Banana Family*). Tropical plants, of which the Banana and Plantain are the type; distinguished by their simple perianth and five or six perfect stamens. The fruit is an important staple of food in the tropics; the gigantic leaves are used in thatching; and the fibres of *Musa textilis* yield *Manilla hemp*, as well as a finer fibre from which some of the most delicate India muslins are made.

941. Ord. Burmanniaceæ consists of small, mostly tropical, annual herbs, commonly with a one-celled ovary and three parietal placentæ, (but in several the ovary is three-celled); differing from Orchidaceæ by their regular flowers with three stamens; and from Iridaceæ by the position of these before the inner divisions of the perianth, the introrse anthers, &c. — *Ex.* *Burmannia* and *Apteria*, of the Southern States.

942. Ord. Iridaceæ (*Iris Family*). Perennial herbs; the flower-stems springing from bulbs; corms, or rhizomas, rarely with fibrous roots, mostly with equitant leaves. Flowers regular or irregular, showy, often springing from a spathe. Perianth with the tube adherent to the three-celled ovary, and usually elongated above it; the limb six-parted, in two series. Stamens three, distinct or monadelphous; the anthers extrorse! Stigmas three, dilated or petaloid! Seeds with hard albumen. — *Ex.* *Iris*, *Crocus*. The rootstocks,

corns, &c. contain starch, with some volatile acrid matter. Those of *Iris cristata* are very pungent; those of *I. versicolor*, &c. are



drastic. *Orris-root* is the dried rhizoma of *Iris florentina*, of Southern Europe. The true *Saffron* consists of the dried orange-colored stigmas of *Crocus sativus*.

943. Ord. Amaryllidaceæ (*Amaryllis Family*). Bulbous plants (sometimes with fibrous roots), bearing showy flowers mostly on scapes. Perianth regular, or nearly so; the tube adherent to the ovary, and often produced above it, six-parted. Stamens six, distinct, with introrse anthers. Stigma undivided or three-lobed. Fruit a three-celled capsule or berry. Seeds with fleshy albumen. — *Ex.* *Amaryllis*, *Narcissus*, *Crinum*, &c.; mostly ornamental plants. The bulbs acrid, emetic, &c.; those of *Hæmanthus* (with whose juice the Hottentots poison their arrows) are extremely venomous. The fermented juice of *Agave* is the intoxicating *Pulque* of the Mexicans. *Hypoxys*, which has been taken as the type of an order, may properly be referred to this family.

FIG. 1239. *Iris cristata*. 1240. The summit of the style, petaloid stigmas, and stamens. 1241. Vertical section of the ovary (the equitant leaves cut away) and long tube of the perianth. 1242. Cross-section of the pod. 1243. Seed. 1244. Enlarged section of the same, showing the embryo, &c.

944. Ord. Bromeliaceæ (*Pine-Apple Family*) consists of American and chiefly tropical plants; with rigid and dry channelled leaves, often with a scurfy surface, a mostly adnate perianth of three sepals and three petals, and six or more stamens; the seeds with mealy albumen. — *Ex.* Ananassa, the Pine-Apple; the fine fruit of which is formed by the consolidation of the imperfect flowers, bracts, and receptacle into a succulent mass. Tillandsia, the Black Moss or Long Moss (which, like most Bromelias, grows on the trunks and branches of trees in the warmer and humid parts of America), has the ovary free from the perianth.

945. Ord. Hamendoraceæ (*Bloodwort Family*) is composed of perennial herbs, with fibrous roots, equitant or ensiform leaves; which, with the stems and flowers, are commonly densely clothed with woolly hairs or scurf. Perianth with the tube either nearly free from, or commonly adherent to, the three-celled ovary; the limb six-cleft, regular. Stamens six, or only three, with introrse anthers. Style single, the stigma standing over the dissepiments of the ovary. Embryo in cartilaginous albumen. — *Ex.* Lachnanthes (Red-Root), Lophiola. — Some have a red juice. The roots are astringent and tonic, especially in Aletris.

946. Ord. Dioscoreaceæ (*Yam Family*) consists of a few twining plants, with large tuberous roots or knotted rootstocks; distinguished among Endogens by their ribbed and netted-veined leaves, with distinct petioles, and by their inconspicuous diœcious flowers, with the perianth in the pistillate flowers adherent to the ovary; the limb six-cleft in two series. Stamens six. Ovary three-celled, with only one or two ovules in each cell: styles nearly distinct. Fruit often a three-winged capsule. Albumen cartilaginous. — *Ex.* Dioscorea. The tubers of one or more species, filled with starch and mucilage (but more or less acrid until cooked), are *Yams*, an important article of food in tropical countries.

947. Ord. Smilacææ (*Smilax Family*) is also remarkable among Endogens for netted-veined leaves. It consists both of herbs and of shrubby plants climbing by tendrils; the perianth is free from the ovary; the mostly three styles or sessile stigmas are entirely distinct; the anthers are introrse; and the fruit is a berry. Embryo minute, in hard albumen. — In the *True Smilax Family*, the flowers are diœcious and axillary; the six divisions of the perianth are alike; the anthers are one-celled, and the few seeds are orthotropous and pendulous. They are mostly shrubby and alternate-leaved

plants. *Ex.* Smilax (Greenbrier, &c.); far the most important species is *S. officinalis* of tropical America, the rootstocks of which are the official *Sarsaparilla*.

948. Subord. Trilliaceæ (*Trillium Family*) consists of low herbs, with whorled leaves and perfect flowers, which in the largest genus, *Trillium*, have a green calyx and a colored corolla; the anthers are two-celled; the seeds anatropous and rather numerous.—The short rootstock of *Trillium* (Fig. 169), called *Birthroot*, has a place in the popular materia medica; but it is doubtful if it really possesses any useful properties.



1245

949. Ord. Liliaceæ (*Lily Family*). Herbs, with the flower-stems springing from bulbs, tubers, or with fibrous or fascicled roots. Leaves simple, sheathing or clasping at the base, parallel-veined. Flowers regular, perfect. Perianth colored, mostly of six parts, or six-cleft. Stamens six: anthers introrse.



1246

Ovary free, three-celled: the styles united into one. Fruit capsular or baccate, with several or numerous seeds in each cell. Albumen fleshy.—This large and widely diffused order comprises a great variety of forms: the Lily, Dog-tooth Violet, and Tulip represent one division; the Tuberose, a second; the Aloe and Yucca, a third; the Hyacinth, the Onion, Leek, and Garlic (*Allium*), and the Asphodel, a fourth; the Asparagus, Lily of the Valley, and Solomon's Seal, a fifth, which is nearly allied to the order Smilaceæ. Acrid and often bitter principles prevail in the order, and are most concentrated in the bulbs, &c., which abound in starchy or mucilaginous matter, and are often edible when cooked. *Squills* are the bulbs of *Scilla maritima* of the South of Europe. *Aloes* is the acrid and bitter inspissated juice of the succulent leaves of species of Aloe. The original *Dragon's-blood* was derived from the juice of the famous Dragon-tree (*Dracæna Draco*) of the East.—The leaves of *Phormium tenax* yield the *New Zealand hemp*, one of the

FIG. 1245 A flower of *Trillium erectum*; a front view. 1246. A diagram of the same.

strongest vegetable fibres known. Many are the ornaments of our gardens and conservatories.



950. Ord. *Melanthaceæ* (*Colchicum Family*). Herbs, with bulbs, corms, or fasciculated roots. Perianth regular, in a double series; the sepals and petals either distinct, or united below into a tube. Stamens six, with extrorse anthers (except in *Tofieldia* and *Pleea*). Ovary free, three-celled, several-seeded: styles distinct. Albumes, fleshy. The true *Melanthaceæ*, or

951. Subord. *Melanthiæ* have a mostly septicidal capsule and a marcescent or persistent perianth. — *Ex.* *Colchicum* has a perianth with a long tube, arising from a subterranean ovary; it is also remarkable for flowering in the autumn, when it is leafless, ripening its fruit and producing its leaves the following spring. In most of the order, the leaves of the perianth are uncombined; as in *Veratrum* (White Hellebore), *Helonias*, &c. Acrid and drastic poisonous plants, with more or less narcotic qualities; chiefly due to a peculiar alkaloid principle, named *Veratria*, which is largely ex-

FIG. 1247. *Erythronium Americanum* (Dog-tooth Violet, Adder's-tongue). 1248. The bulb. 1249. Perianth laid open, with the stamens. 1250. The Pistil. 1251. Cross-section of the capsule.

tracted from the seeds of Sabadilla, or Cebadilla; the produce of *Schœnocaulon officinale*, &c. of the Mexican Andes. The seeds and the corms of *Colchicum* are used in medicine.



952. Subord. Uvulariæ (*Bellheart Family*) has a few-seeded loculicidal capsule or berry, more or less united styles, and a deciduous perianth; the stems from rootstocks. — *Ex.* Uvularia.

953. Ord. Juncaceæ (*Rush Family*). Herbaceous, mostly grass-like plants, often leafless; the small glumaceous flowers in clusters, cymes, or heads. Perianth mostly dry, greenish or brownish, of six leaves (sepals and petals) in two series. Stamens six, or three: anthers introrse. Ovary free, three-celled, or one-celled from the placentæ not reaching the axis; their styles united into one: stigmas three. Capsule three-valved, few- or many-seeded. Albumen fleshy. — *Ex.* Juncus (Rush).

954. Ord. Pontederiaceæ (*Pickereel-weed Family*) comprises a few aquatic plants, with the flowers, either solitary or spicate, arising from a spathe or from a fissure of the petiole; the six-cleft and colored perianth persistent and withering, often adherent to the base of the three-celled ovary; the stamens three, and inserted on the

FIG. 1252. *Colchicum autumnale*; a flowering plant. 1253 Perianth laid open. 1254. Pistil, with the long distinct styles. 1255 Leafy stem and fruit (capsule opening by septical dehiscence). 1256. Capsule divided transversely. 1257. Section of a seed, and a separate embryo.

throat of the perianth, or six, and unequal in situation. Ovules anatropous, numerous; but the fruit often one-celled and one-seeded. — *Ex.* Pontederia (Pickerel-weed), Heteranthera, &c.

955. Ord. Commelynaceæ (*Spiderwort Family*), with usually sheathing leaves; distinguished from other Endogens (except Alismaceæ and Trillium) by the manifest distinction between the calyx and corolla; the former of three herbaceous sepals; the latter of as many delicate colored petals. Stamens six, or fewer: anthers with two separated cells: filaments often clothed with jointed hairs, hypogynous. Ovary two- or three-celled: styles united into one. Capsule few-seeded, loculicidal. Seeds orthotropous. Embryo small, pulley-shaped, partly sunk in the apex of the albumen. — *Ex.* Commelina, Tradescantia (Spiderwort) Mucilaginous plants.

956. Ord. Xyridaceæ. Low, rush-like plants; with ensiform, grassy or filiform radical leaves, sheathing the base of a simple scape, which bears a head of flowers at the apex, imbricated with bracts. Calyx of three glumaceous sepals, caducous. Petals three, with claws, more or less united into a monopetalous tube. Stamens six, inserted on the corolla; three of them bearing extrorse anthers, the others mere sterile filaments. Ovary one-celled, with three parietal placentæ, or three-celled: styles partly united: stigmas lobed. Capsule many-seeded. Seeds orthotropous, albuminous. — *Ex.* Xyris (Yellow-eyed Grass).

957. Ord. Eriocaulonaceæ (*Pipewort Family*). Aquatic or marsh herbs, with much the structure of the preceding; their leaves cellular or fleshy; their minute flowers (monœcious or diœcious) crowded, along with scales or hairs, into a very compact head: the corolla less petaloid than in Xyridaceæ; the six stamens often all perfect; the ovules and seeds solitary in each cell. — *Ex.* Eriocaulon.

958. Ord. Restiaceæ consists of South African and Australian Rush-like plants, with the aspect of Cyperaceæ, but with one-celled anthers and orthotropous seeds.

959. Ord. Cyperaceæ (*Sedge Family*). Stems (*culms*) usually solid, cæspitose. Sheaths of the leaves closed. Flowers one in the axil of each glumaceous bract. Perianth none, or a few bristles. Stamens mostly three, hypogynous. Styles two or three, more or less united. Fruit an achenium. Embryo small, at the extremity of the seed next the hilum. — *Ex.* Cyperus, Scirpus, Carex (Sedges). The herbage is little eaten by cattle. Some Clubrushes are used for making mats, chair-bottoms, &c. The *papyrus* of the Egyptians

was made from the stems of *Cyperus Papyrus*. The tubers of *C. esculentus* are sweet and edible, but are too small to be of much value for food.



960. Ord. Gramineæ (*Grass Family*). Stems (*culms*) cylindrical, mostly hollow, and closed at the nodes. Sheaths of the leaves split or open. Flowers in little spikelets, consisting of two-ranked imbricated bracts; of which the exterior are called *glumes*, and the two that immediately enclose each flower, *paleæ*. Perianth none, or in the form of very small and membranous hypogynous scales, from one to three in number, distinct or united (termed *squamulæ*, *squamellæ*, or *lodiculæ*). Stamens commonly three: anthers versatile. Styles or stigmas two; the latter feathery. Fruit a caryopsis. Embryo situated on the outside of the farinaceous albumen, next the

FIG. 1258. *Scirpus triquetrus*, with its cluster of spikelets. 1259. A separate flower, enlarged, showing its rudimentary perianth of a few denticulate bristles, its three stamens, and pistil with a three-cleft style: *a*, section of the seed, showing the minute embryo. 1260. *Carex Carexana*, reduced in size (flowers monocious, the two kinds in different spikes). 1261. Stem, with the staminate and upper pistillate spike, of the size of nature. 1262. A scale of the staminate spike, with the flower (consisting merely of three stamens) in its axil. 1263. Magnified pistillate flower, with its scale or bract: the ovary enclosed in a kind of sac (*perigynium*), formed by the union of two bractlets. 1264. Cross-section of the perigynium; with the pistil, *p*, removed. 1265. Vertical section of the achenium, showing the seed.

hilum (Fig. 126–128, 622–624).—*Ex.* *Agrostis*, *Phleum*, *Poa*, *Festuca*, which are the principal meadow and pasture grasses: *Oryza* (Rice), *Zea* (Maize), *Avena* (the Oat), *Triticum* (Wheat), *Secale* (Rye), *Hordeum* (Barley), are the chief cereal plants, cultivated for their farinaceous seeds. This universally diffused order is one of the largest of the vegetable kingdom, and doubtless the most important; the floury albumen of the seeds and the nutritious herbage constituting the chief support of man and the herbivorous animals. No unwholesome properties are known in the family except in the grain of Darnel, which is deleterious. *Ergot*, or Spurred Rye, is no exception, being a morbid growth, caused by a parasitic fungus. The stems of grasses frequently contain sugar in considerable quantity (especially when they are solid); as in Maize, the sweet variety of *Sorghum vulgare*, or Broom-Corn, and in Sugar-Cane (*Saccharum officinarum*), which affords the principal supply of this article.



FIG. 1266. One-flowered spikelet or locusta of *Alopecurus*, with the glumes separated. 1267. Same, with the glumes removed: an awn on the back of the outer palea. 1268. One-flowered spikelet of an *Agrostis*. 1269. Pistil of a Grass, showing the two feathery stigmas, and the two hypogynous scales or squamule, larger than usual (representing the perianth). 1270. Two-flowered spikelet of an *Avena*; with the glumes spreading. 1271. One of the flowers with its palea; the exterior pointed, with two bristles or cusps at the apex, and with a bent awn on the back. 1272. Many-flowered spikelet of *Glyceria fluitans*. 1273. An enlarged separate flower of the same, seen from within, showing the inner palea, &c. 1274. The fruit (caryopsis) of the Wheat, with an oblique section through the integuments of the embryo, which is exterior to the albumen. 1275. Detached magnified embryo: *a*, the imperfect cotyledon; *b*, the first leaf of the plumule; *c*, the second leaf of the plumule; *d*, the radicle. 1276. The caryopsis of *Hordeum* (Barley). 1277. A cross-section. 1278. A vertical section, showing the external embryo at the base. 1279. Magnified detached embryo, with its broad cotyledon and the plumule. 1280. More magnified vertical section of the same: *a*, the plumule; *b*, the radicle.

Series II. CRYPTOGRAMOUS OR FLOWERLESS PLANTS.

PLANTS destitute of proper flowers (stamens and pistils), and propagated by spores instead of seeds.

Class III. ACROGENOUS PLANTS.*

Vegetables with a distinct axis, growing from the apex, with no provision for subsequent increase in diameter (containing woody and vascular tissue), and usually with distinct foliage.

961. Ord. Equisetaceæ (*Horsetail Family*). Leafless plants; with striated, jointed, simple or branched stems (containing ducts and some spiral vessels), which are hollow and closed at the joints; each joint terminating in a toothed sheath, which surrounds the base of the one above it. Inflorescence consisting of peltate scales crowded in a terminal spike, or kind of strobile: each with several *thecæ* attached to its lower surface, longitudinally dehiscent. Spores numerous, with four elastic club-shaped bodies (of unknown use), wrapped around them when moist, or spreading when dry.—*Ex.* Equisetum. The epidermis of Equisetum hyemale (the well-known Scouring Rush) contains so much silex that it is used for polishing.



* For illustrations of Classes III. and IV. see the plates of *Manual of the Botany of the Northern United States*.

FIG. 1281. Summit of the stem of *Equisetum sylvaticum*. 1282. Part of the axis of the fructification, with some of the fruit-bearing organs, shown magnified in Fig. 1283, a view from underneath. 1284. A separate *theca*, or spore-case, more magnified. 1285, 1286. Spores, with the club-shaped appendages more magnified.

962. Ord. Filices (*Ferns*). Leafy plants; with the leaves (*fronds*) spirally rolled up or circinate in veneration (except in one suborder), usually rising from prostrate or subterranean rootstocks, or in tree-Ferns from an erect arborescent trunk (Fig. 100), and bearing on the veins of their lower surface, or along the margins, the simple fructification, which consists of one-celled spore-cases (*thecae* or *sporangia*), opening in various ways, and discharging the numerous



minute spores. The stalk or petiole of the frond is termed a *stipe*. — There are four principal suborders, viz.: —

FIG. 1287. *Camptosorus rhizophyllus* (Walking Fern); the fronds rooting, as they frequently do, at the apex; the sori occupying the reticulated veins on the back. 1288. Division (pinnula) of a frond of *Aspidium Goldianum*; the roundish sori attached to the simple veins, and covered with an indusium, which is fastened in the centre, and opens all around the margin. 1289. Magnified sporangium of this division of Ferns, with its stalk, and elastic ring partly surrounding it; which, tending to straighten itself when dry, tears open the sporangium, shedding the minute spores (1290). 1291. *Schizaea pusilla* of about the natural size, with simple and slender radical leaves; the contracted fertile frond pinnate. 1292. A division (pinna) of the fertile frond, magnified, showing the sessile sporangia occupying its lower surface. 1293. One of the sporangia more magnified; they have no proper ring, and open by a longitudinal slit. 1294. *Ophioglossum vulgatum* (Adder's-tongue); the sporangia forming a two-ranked strobilus; a, portion of the spike enlarged, showing the coiled, destitute of a ring, and opening transversely.

963. Subord. Polypodiinæ. Sporangia collected in dots, lines, or variously shaped clusters (*sori* or *fruit-dots*) on the back or margins of the frond or its divisions, or rarely covering the whole surface, stalked, cellular-reticulated, the stalk running into a vertical incomplete ring, which by straightening at maturity ruptures the sporangium transversely on the inner side, discharging the spores. Fruit-dots often covered, at least when young, by a membrane called the *involucre*, or more properly the *indusium*.

964. Subord. Hymenophyllæ. Sporangia borne on a vein extended beyond the margin of the frond into a setiform receptacle, sessile, and surrounded by a horizontal complete ring; otherwise as in the last. — *Ex.* Hymenophyllum, Trichomanes. Ferns of very delicate texture, chiefly tropical.

965. Subord. Osmundinæ. Sporangia variously collected, cellular-reticulated, destitute of any ring (as in *Osmunda* or Flowering Fern), or with an imperfect transverse ring around the top (as in *Schizæa*, Fig. 1293), opening lengthwise by a regular slit.

966. Subord. Ophioglossæ. Sporangia spiked, closely sessile, naked, coriaceous and opaque, not reticulated, destitute of a ring, opening by a transverse slit into two valves, discharging the very copious spores which appear like floury dust. Fronds straight, never rolled up (or circinate) in the bud!

967. Ord. Lycopodiinæ (*Club-Moss Family*). Plants with creeping or erect leafy stems, mostly branching; the crowded leaves lanceolate or subulate, one-nerved. Sporangia single and sessile in the axils of the leaves, sometimes all crowded at the summit under leaves which are changed into bracts and form



FIG. 1295. *Lycopodium Carolinianum*, of the natural size. 1296. A leaf from the spike of fructification, with the spore-case in its axil, and spores falling out. 1297. A group of four larger spores (oöphoridia) of *Selaginella*, magnified. 1298. The same, separated. 1299. A burst spore-case of *Selaginella apus*, with its four large spores.

a kind of ament, one-celled, or rarely two- to three-celled, dehiscent, containing either minute grains, appearing like fine powder, or a few rather large sporules; both kinds often found in the same plant.—*Ex.* Lycopodium (Club-Moss, Ground Pine), Selaginella.—Appended to this family, rather than to the next (with which it has generally been associated), is the

968. Subord. Isoetinae (*Quillwort Family*), consisting of a few acaulescent submersed aquatics, with their sporangia in the axils and immersed in the inflated base of the grassy subulate leaves.—*Ex.* Isoetes.

969. Ord. Hydropterides. Aquatic or marshy cryptogamous plants, of diverse habit, with the fructification borne at the bases of the leaves, or on submerged branches: this consists of two sorts of organs, contained in indehiscent or irregularly bursting involucre (*sporocarps*). It comprises the

970. Subord. Marsilaceae (*Pepperwort Family*); with creeping stems; the leaves long-stalked, circinate in vernalion, and of four orbicordate leaflets in Marsilea, or filiform and destitute of leaflets in Pilularia (the Pillwort).

971. Subord. Salviniæ; which are free floating plants, with alternate and sometimes imbricated sessile leaves; the fructification borne on the stem or branches underneath.—*Ex.* Salvinia, Azolla. (For illustrations, see *Manual of Botany*, Plate 14.)

Class IV. ANOPHYTES.

Vegetables composed of parenchyma alone, with acrogenous growth, usually with distinct foliage, sometimes the stem and foliage confluent into a frond.

972. Ord. Musci (*Mosses*). Low, tufted plants, always with a stem and distinct (sessile) leaves, producing spore-cases which mostly open by a terminal lid, and contain innumerable simple spores. The fertilizing organs, or *antheridia*, have been elsewhere mentioned. In Mosses these accompany the pistillidia; the latter develop into the *capsule*, or more properly the sporangium or spore-case. This is rarely (in Andraea) dehiscent into four valves, or irregularly ruptured (in Phascum, &c.). It usually opens by a lid (*operculum*): beneath the lid and arising from the mouth of the capsule are commonly either one or two rows of rigid processes (collectively the

peristome), which are always some multiple of four: those of the outer row are called *teeth*, of the inner, *cilia*. The spores which fill the cavity commonly appear like an impalpable greenish powder. The pedicel continued through the capsule forms the *columella*: enlarged under the capsule it sometimes forms an *apophysis*. The



calyptra separating early at its base is carried up on the apex of the capsule; if it splits on one side, it is hood-shaped or *cuculliform*, if not, it is mitre-shaped or *mitriform*. The particular structure of all our genera of Mosses, and of the following order, is illustrated in the plates of the *Manual of the Botany of the Northern United States*; to which the student is referred for details.

973. Ord. *Hepaticæ* (*Liverworts*). Frondose or Moss-like plants, of a loose cellular texture, usually procumbent and emitting rootlets from beneath; the calyptra not separating from the base, but usually rupturing at the apex; the sporangium or capsule not opening by a

FIG. 1300. *Mnium cuspidatum*. 1301. The calyptra detached from the spore-case. 1302. Magnified spore-case, from which the lid or operculum, 1303, has been removed, showing the peristome. 1304. A portion of the annulus or ring under the lid, more magnified. 1305. A portion of the outer and inner peristome, highly magnified. 1306. The so-called flowers in a young state, consisting of the pistillidia ♀, and the antheridia ♂, with some cellular jointed threads intermixed; the involucreal leaves cut away. 1307. One of the antheridia more magnified (with some accompanying cellular threads), opening at the apex, and discharging the contents. 1308. Simple peristome of *Splachnum*; the teeth united in pairs. 1309. Double peristome of *Hypnum*; the exterior spreading. 1310. *Physcomitrium* (*Gymnostomum*) *pyriforme*. 1311. Its calyptra, detached from, 1312, the theca. 1313. The lid removed from the orifice, which is destitute of a peristome.

lid, containing spores usually mixed with elaters (which are thin, thread-like cells, containing one or two spiral fibres, uncoiling elastically at maturity). Vegetation sometimes *frondose*, i. e. the stem and leaves confluent into an expanded leaf-like mass; sometimes *foliaceous*, when the leaves are distinct from the stem, as in true Mosses: the leaves are entire or cleft, two-ranked, and often with an imperfect or rudimentary row (*amphigastria*) on the under side of the stem. The matured pistillidium forms the sporangium or capsule, which is either sessile or borne on a long cellular pedicel, and dehiscent by irregular openings, by teeth at its apex, or lengthwise by two or four valves. The *perianth* is a tubular organ enclosing the *calyptra*, which directly includes the pistillidium. Surrounding the perianth are *involucral* leaves of particular forms. The antheridia in the foliaceous species are situated in the axils of perigonal leaves.

974. Subord. *Ricciaceæ* consists of a few chiefly floating plants, rooting from beneath, with their fructification immersed in the frond, the sporangium bursting irregularly. No involucre nor elaters. — *Ex. Riccia*.



975. Subord. *Anthocerotæ*. Terrestrial frondose annuals, with the fruit protruded from the upper surface of the frond. Perianth none. Sporangium pod-like, one- or two-valved, with a free central columella. Elaters none or imperfect.

976. Subord. *Marchantiaceæ* (*True Liverworts*). Frondose and terrestrial perennials, growing in wet places, with the fertile receptacle raised on a peduncle, capitate or radiate, bearing pendent calyptrate

FIG. 1314, 1315. *Riccia natans*, about the natural size. 1316. Magnified section through the thickness of the frond, showing the immersed sporangia; one of which has burst through and left an effete cavity. 1317. Magnified vertical section of one of the sporangia, with the contained spores. 1318. Sporangium torn away from the base, and a quaternary group of spores, united and separated.

sporangia from the under side: these open variously, but are not four-valved. Elaters with two spiral fibres.



977. Subord. *Jungermanniaceæ*. Frondose or mostly foliaceous plants; with the sporangium dehiscent into four valves, and the spores mixed with elaters.

CLASS V. THALLOPHYTES.

Vegetables composed of parenchyma alone, forming a mass or stratum (*thallus*, 109, 727), or consisting of a congeries of cells, never exhibiting a marked distinction into root, stem, and foliage, or into axis and leaves.

978. Ord. *Lichenes* (*Lichens*) form the highest grade of this lower series. They consist of flat expansions, which are rather crustaceous than foliaceous; while some are nearly pulverulent. In several the vegetation rises into a kind of axis, or imitates stems and branches; as in the *Cladonia coccinea*, which abounds on old logs (Fig. 1327); or in *Cladonia rangiferina*, the Reindeer Moss; also in *Usnea*, where it forms long, gray tufts, hanging from the boughs of old trees in our Northern forests. Lichens are never aquatic, but grow on the ground, on the bark of trees, or on exposed rocks, to which the proper rock-Lichens adhere by their lower surface, with great tenacity, while by

FIG. 1319. *Steetzia Lyellii*, with the young fructification still included in the tubular perianth. 1320. Dehiscent sporangium of a *Jungermannia*, on its fruit-stalk, with some of the leaves at its base, magnified enough to exhibit its cellular structure. 1321. Two elaters from the same (*a*, in an entire state; *b*, with only the threads remaining), and some spores, highly magnified.

the upper they draw their nourishment directly from the air. The fructification is in *cups*, or *shields* (*apothecia*), resting on the surface of the thallus, or more or less immersed in its substance, or else in pulverulent spots scattered over the surface. A magnified section through an apothecium (Fig. 1324) brings to view a stratum of elongated sacs (*asci*), with filaments intermixed, as seen detached and highly magnified at Fig. 1325. Each *ascus*, or sac, contains a few spores: these divide into two, which, however, generally remain



coherent. For a description of the Lichens of this country, the student is referred to Professor Tuckerman's *Synopsis of the Lichenes of New England, the other Northern States, &c.* and to his *Lichenes Amer. Sept. Exsiccati*, illustrating them by named specimens.

FIG. 1322. A stone upon which several Lichens are growing, such as (passing from left to right) *Parmelia conspersa*, *Sticta miniata*, *Lecidea geographica* (so called from its patches resembling the outline of islands, &c. on maps), &c., &c. 1323. Piece of the thallus of *Parmelia conspersa*, with a section through an apothecium. 1324. Section of a smaller apothecium, more magnified. 1325. Two *asci* and their contained spores, with the accompanying filaments, highly magnified. 1326. Section of a piece of the thallus of *Sticta miniata*, showing the immersed apothecia. 1327. *Cladonia coccinea*, bearing its fructification in rounded red masses on the edges of a raised cup.

979. Ord. Fungi (*Mushrooms, Moulds, &c.*) are parasitic (150, 153) flowerless plants, either in a strict sense, as living upon and drawing their nourishment from living, though more commonly languishing, plants and animals, or else as appropriating the organized matter of dead and decaying animal and vegetable bodies. Hence they fulfil an office in the economy of creation analogous to that of the infusory animalcules. Those Fungi which produce Rust, Smut, Mildew, &c. are of the first kind; those which produce Dry-rot, &c. hold a somewhat intermediate place; and Mushrooms, Puff-balls, &c. are examples of the second. Fungi are consequently not only destitute of anything like foliage, but also of the green matter, or chlorophyll, which appears to play an essential part in vegetable assimilation. A full account of the diversified modifications of structure that Fungi display, and of the remarkable points in their economy, would require a large volume. We will notice three sorts only, which may represent the highest, and nearly the lowest, forms of this vast order or class of plants. They all begin (in germination or by offsets) with the production of copious filamentous threads, or series of attenuated cells, appearing like the roots of the fungus that arises from them (Fig. 1328, 1330), and to a certain extent performing the functions of roots: this is called the *mycelium*, and is the true vegetation of Fungi. The subsequent developments properly belong to the fructification, or are analogous to tubers, rhizomas, &c. In one part of the order, the masses that arise, of various definite shapes, and often attaining a large size, contain in their interior a multitude of *asci* (Fig. 1329), enclosing simple or double sporules, just as in Lichens. The esculent Morel has this kind of fructification; as well as the less conspicuous *Sphaeria* (Fig. 1328), which is in other respects of a lower grade. The Agarics, like the Edible Mushroom (Fig. 1330), produce their spores in a different way. Rounded tubercles appear on the mycelium; some of these rapidly enlarge, burst an outer covering which is left at the base (the *volva*, or *wrapper*), and protrude a thick stalk (*stipes*), bearing at its summit a rounded body that soon expands into the *pileus*, or *cap*. The *lamellæ*, or *gills* (*hymenium*), that occupy its lower surface, consist of parallel plates (Fig. 1331), which bear naked sporules over their whole surface. A careful inspection with the microscope shows that these sporules are grouped in fours; and a view of a section of one of the gills shows their true origin (Fig. 1332). Certain of the cells (*basidia*), one of which is shown more

magnified at Fig. 1333, produce four small cells at their free summit, apparently by gemmation and constriction: these are the spores. It is maintained that the larger intermingled cells, (of which one is shown at Fig. 1332; *a*.) filled with an attenuated form of matter, are the analogues of antheridia. The lowest Fungi produce from their mycelium only simple or branching series of cells (Fig. 92-94). The mycelium itself either ramifies through decaying organized matter, as the Moulds, &c.; or else — like the Blight and Rust in grain, and the *Muscardine* so destructive to silkworms, and others



so destructive to the Grape, the Potato, &c. — it attacks and spreads throughout living tissues, often producing great havoc before its fructification is revealed at the surface. Sometimes the last cells of the stalks swell into a vesicle, in which the minute sporules are formed; as in Fig. 92. Sometimes the branching stalks bear single sporules, like a bunch of grapes (Fig. 94), or long series of cells, or

FIG. 1328. *Sphaeria rosella*. 1329. Asci from its interior, containing sporules, highly magnified. 1330. *Agaricus campestris*, the Edible mushroom, in its various stages. 1331. Section through the pileus, to display the gills. 1332. A small piece of a slice through the thickness of one of the gills, magnified; showing the spores borne on the summit of salient cells of both surfaces. 1333. One of the sporule-bearing cells, with some subjacent tissue, more magnified.

sporules, in rows, like the beads of a necklace (Fig. 93), which, separating, become the rudiments of new plants.

980. Ord. Algæ (*Seaweeds*). This vast order consists of aquatic plants, for the most part strictly so, but some grow in humid terrestrial situations. The highest forms are the proper Seaweeds (*Wrack, Tang, Dulse, Tangle, &c.*); "some of which have stems exceeding in length (although not in diameter) the trunks of the tallest forest-trees, while others have leaves (*fronds*) which rival in expansion those of the Palm." "Others again are so minute as to be wholly invisible, except in masses, to the naked eye, and require the highest powers of our microscopes to ascertain their form and structure." Some have the distinction of stems and fronds; others show simple or branching solid stems only; and others flat foliaceous expansions alone (Fig. 95), either green, olive, or rose-red in hue. From these we descend by successive gradations to simple or branching series of cells placed end to end, such as the green Confevas of our pools, and many marine forms: we meet with congeries of such cells capable of spontaneous disarticulation, each joint of which becomes a new plant, so that the organs of vegetation and of fructification become at length perfectly identical, both reduced to mere cells; and finally, as the last and lowest term of possible vegetation, we have the plant reduced to a single cell, giving rise to new ones in its interior, each of which becomes an independent plant (Fig. 79-83, 18-22). Our Algæ should be studied by the aid of the admirable *Nereis Boreali-Americana, or History of the Marine Algæ of North America*, by Professor Harvey, published by the Smithsonian Institution. For the fresh-water species we have no American work. The main divisions of Algæ are into the following suborders.

981. Subord. Melanospermeæ, or Fucaceæ, the *Olive-green Seaweeds*; having dark-colored spores and generally an olive-green color, such as the common Rockweed, Gulfweed, &c. The fertilization of these spores has already been described (661).

982. Subord. Rhodospermeæ, or Florideæ, the *Rose-red Seaweeds*, so called from their prevailing color. These, the most beautiful of Algæ (including the Dulse, Laver, &c.) have two kinds of spores; one large, simple, and superficial; the others dispersed through the interior of the frond, and formed four together in a mother cell.

983. Subord. Chlorospermeæ, the *Bright-green Algæ*, the spores and the vegetation of which are generally of a lively green hue, are more

simple in structure, and include the fresh-water kinds generally, as well as numerous marine species; among them those of single rows of cells, or of single cells (100-105, 656-660). Some of these fructify by conjugation (655-657), as is the case in those simplified forms which compose the

984. Subord. Desmidiaceæ, which are microscopic and infusory green Algae of single cells (Fig. 100, 655), often of crystal-like forms, invested with mucus, and belonging to fresh water. They multiply largely by division, but strictly *propagate* only by conjugation. Many of them have long been claimed for the animal kingdom, or esteemed of ambiguous nature, on account of the free movements

they exhibit; but this affords no real distinction. (Chap. XII, XIII.) More ambiguous still, and on the lowest confines of the vegetable kingdom, are those minute vegetables, as they doubtless are, which constitute the

985. Subord. Diatomaceæ. These differ from the last chiefly in the brown instead of green color of their contents, in the siliceous and durable nature of their cell-wall, and in being natives of salt instead of fresh water. Their movements, as they break up from their connections, are still more vivid and varied. Some are fixed; others are free. Some are extremely minute: others form clusters of cells of considerable size. All require a compound microscope for their study, and a full treatise is needed to do them justice.



986. Ord. Characeæ. The *Chara* Family consists of a few aquatic plants, which have all the simplicity of the lower Algae in their vegetation, being composed of simple tubular cells placed end to end, and often with a set of smaller tubes applied to the surface of the main one (Fig. 1335, 1336). Hence they have been placed among Algae. But their fructification is of a higher order. It consists of two kinds of bodies (both shown in Fig. 1335), of which

FIG. 1334 Branch of the common *Chara*, nearly the natural size. 1335 A portion magnified, showing the lateral tubes enclosing a large central one (a portion more magnified at 1336); also a spore, invested by a set of tubes twisted spirally around it; and the antheridium borne at its base.

the smaller (and lower) contains antheridia of curious structure, provided with slender and active spermatozoids, while the upper and larger is a sporocarp, formed of a budding cluster of leaves wrapped around a nucleus, which is a spore or sporangium. The order might perhaps have been introduced between the Equisetaceæ (to which the verticillate branches show some analogy) and the Hydropterides; but its true position is hard to determine.

CHAPTER IV.

OF THE ARTIFICIAL SYSTEM OF LINNÆUS.

987. THE difference in principle between an artificial and a natural system of classification has already been indicated (715). No one better understood this than Linnæus, when, finding it impossible in his day to make a natural classification available for ordinary use, he proposed, as a temporary substitute, the elegant artificial scheme which bears his name. As this system is identified with the history of the science, which in its time it so greatly promoted, and as most systematic works have until recently been arranged upon its plan, it is still necessary for the student to understand it. Its principles are so simple, that a brief space will amply suffice for its explanation.

988. It must be kept in mind, that an artificial scheme does not attempt to fulfil all the conditions of natural-history classification. Its principal object is to furnish an easy mode of ascertaining the names of plants; their relationships being only so far expressed as the plan of the scheme admits. All higher considerations are of course sacrificed to facility. In the Linnæan classification, the species of a genus are always kept together, whether or not they all accord with the class or order under which they are placed. Its lower divisions, therefore, namely, the genera and species, are the same as in a natural system. But the genera are arranged in artificial classes and orders, founded on some single technical character, and have no necessary agreement in any other respect; just as words are alphabetically arranged in a dictionary, for the sake of convenience, although those which stand next each other have, it may be, nothing in common beyond the initial letter.

989. The classes and orders Linnæus founded entirely upon the number, situation, and connection of the stamens and pistils; the office and importance of which he had just set in a clear light.

990. The classes, twenty-four in number, were founded upon modifications of the stamens, and have names of Greek derivation expressive of their character. The first eleven comprise all plants with perfect flowers, and with a definite number of equal and unconnected stamens. They are distinguished by the absolute number of these organs, and are designated by names compounded of Greek numerals and the word *andria* (from *άνηρ*), which is used metaphorically for stamen, as follows:—

Class 1. MONANDRIA includes all such plants with one stamen to the flower; as in *Hippuris*.

2. DIANDRIA, those with two stamens, as in the Lilac.
3. TRIANDRIA, with three stamens, as in the Valerian, &c.
4. TETRANDRIA, with four stamens, as in the Scabious.
5. PENTANDRIA, with five stamens, the most frequent case.
6. HEXANDRIA, with six stamens, as in the Lily Family, &c.
7. HEPTANDRIA, with seven stamens, as in Horsechestnut.
8. OCTANDRIA, with eight stamens, as in Evening Primrose, &c.
9. ENNEANDRIA, with nine stamens, as in the Rhubarb.
10. DECANDRIA, with ten stamens, as in Rhododendron.
11. DODECANDRIA, with twelve stamens, as in *Asarum* and the Mignonette; extended also to include those with from thirteen to nineteen stamens.

991. The two succeeding classes include plants with perfect flowers, having twenty or more unconnected stamens, which, in

12. ICOSANDRIA, are inserted on the calyx (perigynous, 467), as in the Rose Family; and in
13. POLYANDRIA, on the receptacle (hypogynous, 466), as in the Buttercup, *Anemone*, &c.

992. Their essential characters are not indicated by their names; the former merely denoting that the stamens are twenty in number; the latter, that they are numerous. — The two following depend upon the relative length of the stamens, namely,

14. DIDYNAMIA, including those with two long and two short stamens (Fig. 407); and
15. TETRADYNAMIA, those with four long and two short stamens, as in Cruciferous flowers (Fig. 406).

993. Their names are Greek derivatives, signifying in the former that two stamens, and in the latter that four stamens, are most powerful. — The four succeeding are founded on the connection of the stamens:—

16. **MONADELPHIA** (meaning a single fraternity), with the filaments united in a single set, tube, or column, as in all the Mallow Family, &c.
17. **DIADELPHIA** (two fraternities), with the filaments united in two sets or parcels.
18. **POLYADELPHIA** (many fraternities), with the filaments united in more than two sets or parcels.
19. **SYNGENESIA** (from Greek words signifying to grow together), with the anthers united in a ring or tube, as in all Compositæ (844).

994. The next class, as its name denotes, is founded on the union of the stamens to the style:—

20. **GYNANDRIA**, with the stamens and styles consolidated, as in the Orchis Family (Fig. 468).

995. In the three following classes, the stamens and pistils are found in separate blossoms:—

21. **MONŒCIA** (one household) includes all plants where the stamens and pistils are in separate flowers on the same individual; as in the Oak, &c.
22. **DIGECIA** (two households), where they occupy separate flowers on different individuals; as in the Willow, Poplar, Moonseed (Fig. 413, 414), &c.
23. **POLYGAMIA**, where the stamens and pistils are separate in some flowers and united in others, either on the same, or two or three different plants; as in most Maples.

996. The only remaining class,

24. **CRYPTOGAMIA**, is inferred to have concealed stamens and pistils (as the name imports), or the analogues of these organs, and includes the Ferns, Mosses, Lichens, &c., which are now commonly termed Cryptogamous or Flowerless Plants (651).

997. The characters of the classes may be presented at a single view, as in the subjoined analysis:—

SYNOPTICAL VIEW OF THE LINNAEAN CLASSES.

		Stamens		Flowers		Classes	
		1	2	1	2	1	2
of equal length :	unconnected with each other, and	the stamens separate from the pistils,	both found in the same flower,	stamens and pistils manifest,	in separate flowers	1. MONANDRIA.	1. MONANDRIA.
						2. DIANDRIA.	2. DIANDRIA.
						3. TRIANDRIA.	3. TRIANDRIA.
						4. TETRANDRIA.	4. TETRANDRIA.
						5. PENTANDRIA.	5. PENTANDRIA.
						6. HEXANDRIA.	6. HEXANDRIA.
						7. HEPTANDRIA.	7. HEPTANDRIA.
						8. OCTANDRIA.	8. OCTANDRIA.
						9. ENNEANDRIA.	9. ENNEANDRIA.
						10. DECANDRIA.	10. DECANDRIA.
of unequal length :	connected with each other	the stamens adherent to the pistil	both found in the same flower,	stamens and pistils manifest,	in separate flowers	11. DODECANDRIA.	11. DODECANDRIA.
						12. ICOSANDRIA.	12. ICOSANDRIA.
						13. POLYANDRIA.	13. POLYANDRIA.
						14. DIDYMANIA.	14. DIDYMANIA.
						15. TETRADYMANIA.	15. TETRADYMANIA.
						16. MONADLPHIA.	16. MONADLPHIA.
						17. DIADLPHIA.	17. DIADLPHIA.
						18. POLYADLPHIA.	18. POLYADLPHIA.
						19. SYNGENIA.	19. SYNGENIA.
						20. GYNANDRIA.	20. GYNANDRIA.
the stamens and pistils concealed, or none	the stamens and pistils concealed, or none	the stamens and pistils concealed, or none	the stamens and pistils concealed, or none	the stamens and pistils concealed, or none	the stamens and pistils concealed, or none	21. MONGEA.	21. MONGEA.
						22. DIOGIA.	22. DIOGIA.
						23. POLYGAMA.	23. POLYGAMA.
						24. OUSTROGAMA.	24. OUSTROGAMA.

998. The orders, in the first thirteen classes of the Linnæan artificial system, depend on the number of styles, or of the stigmas when the styles are wanting; and are named by Greek numerals prefixed to the word *gynia*, used metaphorically for pistil, as follows:—

- Order 1. MONOGYNIA embraces all plants of any of the first thirteen classes, with one style to each flower.
2. DIGYNIA embraces those with two styles.
 3. TRIGYNIA, those with three styles.
 4. TETRAGYNIA, those with four styles.
 5. PENTAGYNIA, those with five styles.
 6. HEXAGYNIA, those with six styles.
 7. HEPTAGYNIA, those with seven styles.
 8. OCTOGYNIA, those with eight styles.
 9. ENNEAGYNIA, those with nine styles.
 10. DECAGYNIA, those with ten styles.
 11. DODECAGYNIA, those with eleven or twelve styles.
 12. POLYGYNIA, those with more than twelve styles.

999. The orders of class 14, Didynamia, are only two; namely,

1. GYMNOSPERMIA, meaning seeds naked, the achenia-like fruits having been taken for naked seeds.
2. ANGIOSPERMIA, with the seeds evidently in a seed-vessel or pericarp.

1000. The 15th class, Tetradynamia, is also divided into two orders, which are distinguished merely by the form of the pod:—

1. SILICULOSA; the fruit a silicle (621), or short pod.
2. SILIQUOSA; fruit a silique (620), or more or less elongated pod.

1001. The orders of the 16th, 17th, 18th, 20th, 21st, and 22d classes depend merely on the number of stamens; that is, on the characters of the first thirteen classes, whose names they likewise bear: thus,

Order 1. MONANDRIA, with one stamen; 2. DIANDRIA, with two stamens; and so on.

1002. The orders of the 19th class, Syngenesia, are six; namely,

1. POLYGAMIA ÆQUALIS, where the flowers are in heads (compound flower, 394), and all perfect.

2. **POLYGAMIA SUPERFLUA**, the same as the last, except that the rays, or marginal flowers of the head, are pistillate only.
 3. **POLYGAMIA FRUSTRANEA**, those with the marginal flowers neutral (Fig. 324, 325), the others perfect.
 4. **POLYGAMIA NECESSARIA**, where the marginal flowers are pistillate and fertile, and the central, staminate and sterile.
 5. **POLYGAMIA SEGREGATA**, where each flower of the head has its own proper involucre.
 6. **MONOGAMIA**, where solitary flowers (that is, not united into a head) have united anthers, as in *Lobelia*.
1003. The 23d class, *Polygamia*, has three orders, founded on the characters of the two preceding classes ; namely,
1. **MONŒCIA**, where both separated and perfect flowers are founded in the same individual.
 2. **DIOŒCIA**, where they occupy different individuals.
 3. **TRIOŒCIA**, where one individual bears the perfect, another the staminate, and a third the pistillate flowers.
1004. The orders of the 24th class, *Cryptogamia*, are natural orders, and therefore not definable by a single character. They are,
1. **FILICES**, the Ferns.
 2. **MUSCI**, the Mosses.
 3. **ALGÆ**, which, as left by Linnæus, comprised the *Hepaticæ*, Lichens, &c., as well as the Seaweeds.
 4. **FUNGI**, Mushrooms, &c.

APPENDIX.

OF THE SIGNS AND ABBREVIATIONS EMPLOYED IN BOTANICAL WRITINGS.

LINNÆUS adopted the following signs for designating the duration of a plant, viz. :—

- ☉ An annual plant.
- ♂ A biennial plant.
- ℥ A perennial herb.
- h A shrub or tree.

Among the signs recently introduced, the following have come into general use :—

- ⊙ A monocarpic (once-flowering) plant, whether annual or biennial.
- ① An annual plant.
- ② A biennial plant.
- ℥ A perennial herb.
- h A plant with a woody stem.
- ♂ A staminate flower, or plant.
- ♀ A pistillate flower, or plant.
- ⚥ A perfect flower, or a plant bearing perfect flowers.

! The exclamation point is employed as the counterpart of the note of interrogation. When it follows the name of an author appended to the name of a plant, it imports that an authentic specimen of the plant in question, under this name, has been examined by the writer : when it is appended to a locality, it signifies that the writer has seen or collected specimens of the plant from that locality, &c.

? The note of interrogation is employed to denote doubt or uncertainty ; and is affixed either to a generic or specific name, or to that of an author or locality cited.

* As used by De Candolle, indicates that a good description is found at the reference to which it is appended. It is not in common use.

Those abbreviations of the names of organs which are commonly employed, such as *Cal.* for calyx, *Cor.* for corolla, *Fl.* for flower, *Fr.* for fruit, *Gen.* for genus, *Hab.* for habitat, *Herb.* for herbarium, *Hort.* for garden, *Mus.* for Museum, *Ord.* for order, *Rad.* (*Radix*) for root, *Syn.* for synonymy, *Sp.* or *Spec.* for species, *Var.* for variety, &c., scarcely require explanation.

V. sp. denotes, in general terms, that the writer has seen the plant under consideration.

V. s. c. (*Vidi siccam cultam*), that a dried specimen of a cultivated plant has been examined.

V. s. s. (*Vidi siccam spontaneam*), that a dried specimen of the wild plant has been examined.

V. v. c. (*Vidi vivam cultam*), that the living cultivated plant has been under examination.

V. v. s. (*Vidi vivam spontaneam*), that the wild plant has been examined in a living state.

The names of authors, when of more than one syllable, are commonly abridged by writing the first syllable, and the first letter or the first consonant of the second. Thus, *Linn.*, or *L.*, is the customary abbreviation for Linnæus; *Juss.* for Jussieu; *Willd.* for Willdenow; *Muhl.* for Muhlenberg; *Michx.* for Michaux; *Rich.* for Richard; *De Cand.*, or *DC.*, for De Candolle; *Hook.* for Hooker; *Endl.* for Endlicher; *Lindl.* for Lindley, &c.

OF COLLECTING AND PRESERVING PLANTS.

1. THE botanist's collection of specimens of plants, preserved by drying under pressure between folds of paper, is termed a *Hortus Siccus*, or commonly an *Herbarium*.

2. A complete specimen consists of one or more shoots, bearing the leaves, flowers, and fruit; and, in case of herbaceous plants, a portion of the root is also desirable.

3. Fruits and seeds which are too large to accompany the dried specimens, or which would be injured by compression with sections of wood, &c., should be separately preserved in cabinets.

4. Specimens for the herbarium should be gathered, if possible, in a dry day; and carried either in a close tin box, as is the common practice, or in a strong portfolio, containing a quire or more of firm paper, with a few loose sheets of blotting-paper to receive delicate plants. They are to be dried under strong pressure, (but without crushing the parts,) between dryers composed of six to ten thicknesses of bibulous paper; which should be changed daily, or even more frequently, until all the moisture is extracted from the plants;—a period which varies in different species, and

with the season, from two or three days to a week. All delicate specimens should be laid in folded sheets of thin and smooth bibulous paper (such as tea-paper), and such sheets, filled with the freshly gathered specimens, are to be placed between the dryers, and so transferred entire, day after day, into new dryers, without being disturbed, until perfectly dry. This preserves all delicate flowers better than the ordinary mode of shifting of the papers which are in immediate contact with the specimens, and also saves much time usually lost in transferring numerous small specimens, one by one, into dry paper, often to the great injury of the delicate corolla, &c.

5. The dried specimens, properly ticketed with the name, locality, &c., and arranged under their respective genera and orders, are preserved in the herbarium, either in separate double sheets, or with each species attached by glue or otherwise to a half-sheet of strong white paper, with the name written on one corner. These are collected in folios, or else lie flat (as is the best mode) in parcels of convenient size, received into compartments of a cabinet, with close doors, and kept in a perfectly dry place.

6. The seeds of plants intended for cultivation, which are to be transported to a distance before being committed to the earth, should first be dried in the sun, wrapped in coarse paper, and preserved in a dry state. They should not be packed in close boxes, at least so long as there is danger of the retention of moisture.

7. Roots, shrubs, &c., designed for cultivation, should be taken from the ground at the close of their annual vegetation, or early in the spring before growth recommences, and packed in successive layers of slightly damp (but not wet) Peat-moss (*Sphagnum*). Succulent plants, however, such as Cacti, may be packed in dry sand.

8. Plants in a growing state can only be safely transported to a considerable distance, especially by sea, in the closely glazed cases invented by Mr. Ward;* where they are provided with the requisite moisture, while they are sufficiently exposed to the light.

* On the Growth of Plants in Closely Glazed Cases, by N. B. Ward, F. L. S., London, 1842. — Ed. 2, 1853.

GLOSSARY

OF ENGLISH BOTANICAL TERMS, EMPLOYED IN BOTANICAL
DESCRIPTIONS, COMBINED WITH AN

INDEX.

[The numerals without any prefix refer to the pages of the work: those preceded by fig. to figures.]

- A**, privative, as the initial in many words of Greek derivation, signifies the absence of the organ mentioned; as, *apetalous*, destitute of petals; *aphyllous*, leafless. In words beginning with a vowel this prefix is changed to *an*; as, *ananthous*, flowerless; *anatherous*, destitute of anthers.
- Abbreviations.** The customary ones are mentioned on p. 518.
- Aberrant** (wandering): applied to species, genera, &c. which differ in some respect from the usual or normal character of the group they belong to.
- Abietinæ**, 480.
- Abnormal**: differing from the *normal* or usual structure.
- Aboriginal**: strictly native; indigenous.
- Abortion**: the non-formation or imperfect formation of an organ, 255.
- Abortive organs**, 258.
- Abrupt**: terminating suddenly.
- Abruptly pinnate**, 163, fig. 290.
- Absorption**, 80.
- Acanthaceæ**, 447.
- Acanthoclados**: with spiny branches.
- Acanthophorous**: spine-bearing.
- Acaulescent**: stemless, or apparently so, i. e. without a proper *caulis*; 91.
- Accessory**: something additional.
- Accessory buds**, 98.
- Accessory fruits**, 318.
- Accrescent**: increasing in size after flowering, as the calyx of *Physalis*.
- Accrete**: grown together.
- Accumbent**: lying against, especially edgewise against another body; 326, 390, fig. 700.
- Acéphalous**: headless.
- Aceráceæ**, or **Acerinæ**, 410.
- Acerose**: needle-shaped, like the leaves of Pines, &c.; 166, fig. 212, 213.
- Acetabuliform** or **acetabulous**: saucer-shaped.
- Achenium** (pl. *achenia*): a one-seeded seed-like fruit; 313, fig. 566-573.
- Achlamydeous**: destitute of calyx and corolla, 261.
- Acids**, 56, 195.
- Acicular**: slender needle-shaped or bristle-shaped.
- Acies**: the edge of a thing.
- Acindciform**: scymitar-shaped, like some bean-pods.
- Acnes** (*acini*): the separate grains or carpels of an aggregate fleshy fruit, like the raspberry, as the term is now generally used; classically, the *acinus* meant the whole bunch of such fruits.
- Acotyledonous**: destitute of cotyledons.
- Acrobryous**: budding from the apex only; same as
- Acrogeous**: growing from the apex, 370.
- Acrogens**, **Acrogeous plants**, 370, 499.
- Acramphibryous**: growing from both ends and over the surface.
- Aculeate**: prickly; beset with prickles (*aculeæ*); 52.

- Aculeolate*: diminutive of the last: i. e. beset with small or few prickles.
- Acuminate*: ending in a narrowed or prolonged and tapering point; 162, fig. 268, 239.
- Acutangular*: sharp-angled; as the stems of *Scirpus pungens*.
- Acute*: merely sharp-pointed; ending by an acute angle; 162, fig. 269.
- Adelphous* (stamens): joined by their filaments or clustered into a brotherhood (*adelpchia*).
- Adherent*: sticking to, or, commonly, growing fast to, another body, 252.
- Adnate*: grown fast to, or formed in union with, another body, as the calyx-tube of the Gooseberry and Cranberry (fig. 391) to the ovary, 251, 252. Attached by its whole length, as the anther of *Liriodendron*, 282, fig. 470, and of *Asarum*, fig. 472.
- Adnation*: the union of heterogeneous parts, 250.
- Adpressed*, or *appressed*: brought into contact or nearly, but not united.
- Adscendent*, or *ascending*: rising gradually upwards, 102.
- Adurgent*, or *assurgent*: rising upwards
- Adventitious*, *adventive*: found out of the natural place.
- Adventitious buds*, 82, 98.
- Æquilateral*: equal-sided; opposed to oblique.
- Aerial*: growing in the air.
- Aerial roots*, 85.
- Aerophyte*: same as Air-plant.
- Æstival*: relating to summer.
- Æstivation*: arrangement of floral organs in the bud, 269.
- Affinity*: true and near relationship; i. e. species have affinity when they resemble each other in their principal points of structure, or, in other words, are constructed throughout upon the same particular plan or type. (See *Analogy*.)
- Agamous* or *Agamic*: destitute of sexes.
- Agglomerate* or *aggregate*: heaped or crowded into a cluster.
- Aggregate fruits*, 317.
- Air-cells*, *air-passages*, 50.
- Air-plants*, 87.
- Akenium* or *akene*: see *achenium*.
- Ala* (pl. *alae*): a wing; the side petals of a papilionaceous flower; 253, fig. 392, b.
- Alabâstrum*: a flower-bud.
- Alar*: borne in the forks of a stem.
- Alate*: winged; i. e. furnished with any broad and thin adherent appendage, as the seeds of Trumpet Creeper, fig. 601, the leafstalks of the Orange, *Rhus Copallina*, &c., and the stem of the common Thistle.
- Albescent*: whitened, or hoary-white.
- Albumen*, a vegetable product, 198.
- Albumen* of the seed, 76, 322.
- Albuminous* (seeds): furnished with albumen, 323.
- Alburnum*: sapwood, 126.
- Algæ*, 509.
- Algology*: the science relating to Algæ.
- Alismaceæ*, 487.
- Alkaloids*, 57.
- Alliaceus*: like the garlic or onion.
- Alliances*: natural groups of nearly related orders, 374.
- Allspice*, 418.
- Almond*, 415, 417.
- Alpine*: growing on the higher parts of the Alps, and in general on mountains above the limits of trees.
- Aloes*, 493.
- Alsineæ*, 395.
- Alternate* (leaves): situated one after another, 78, 97, 133. Petals, stamens, &c. are said to alternate with adjacent organs, when they stand over the intervals between them, 235.
- Alternation of parts*, 235.
- Alveolate*: honeycombed; having deep angular cavities separated by thin partitions, as the receptacle of Cotton-Thistle, fig. 898.
- Amarantaceæ*, 465.
- Amarylhidaceæ*, 491.
- Ament*: a catkin; a peculiar scaly spike; 213, fig. 312.
- Amentaceous*: resembling or bearing catkins.
- Amnios*: the embryo-sac, 304.
- Amorphous*: shapeless, i. e. of no definite or regular form.
- Amphibryous*: growing by additions over the whole periphery.
- Amphicarpous*, or *amphicarpic*: producing two kinds of fruit; as in the genus *Amphicarpæa*, so named on this account.
- Amphigastria*: the peculiar stipule-like leaves of certain Hepaticæ, 504.
- Amphitropous*, or *amphitropal*, ovule or seed, 300, fig. 528.
- Amplectant*: embracing.
- Amplexicaul* (leaves, &c.): clasping the stem by a broad base or insertion.
- Ampullaceous*: shaped like an ampulla or flask-shaped vessel; swelling out at the base or middle.
- Amygdalæ*, 415.
- Amylaceous*: composed of starch (*amylum*), or resembling starch.

Amyloid, 55.

Amyridaceæ, 407.

Anacardiaceæ, 406.

Analogy: resemblance in certain respects. As distinguished from *affinity* it means resemblance in certain respects only, not in the whole plan of structure. Thus a Ranunculus is *analogous* to a Potentilla, but there is no near affinity or relationship between the two. And the tendrils of a Pea, that of a Smilax, and that of the Grape-Vine are *analogues*, i. e. are *analogous* organs, but are not *homologues*; for the first answers to a leaf, the second to stipules, and the third to a stem. The spur of a Larkspur (fig. 398) is analogous to one of the five spurs of Columbine (fig. 646), but not homologous with it, for the first is a sepal, and the second a petal.

Andrôdrous: destitute of stamens.

Anâtherous: destitute of anthers.

Ananthous: without flowers.

Andstomosing: connected by cross branches into a network, as the veins of animals, and the so-called veins of reticulated leaves, 49, 54.

Andropous, or antitropal, seeds or ovules, 299, fig. 529.

Ancipital: with two edges, as the stem of Sisyrinchium anceps.

Andræcium: the stamens of a flower, taken as a whole, 223.

Andrôgynous: bearing both stamens and pistils in separate flowers of the same inflorescence.

Androphore: a column of united stamens, or any support on which the stamens are raised.

Androus, in words of Greek derivation, refers to the stamens: see *dian-drous*, &c.

Androspores, 335.

Anfractuose or anfractuous: abruptly bent hither and thither, as the stamens of Melon, fig. 467.

Angiospermia, 515.

Angiospermous (*Angiospermæ*, *Angiosperms*): producing seeds in a pericarp, 371, 375.

Angostura bark, 406.

Angular divergence of leaves, 135.

Anise, 426.

Anisômerous (flower): of unequal number in the different circles; unsymmetrical.

Anisophyllous: unequal-leaved, as when the two leaves of the same pair are of unequal size.

Anisotémoneous: when the number of

the stamens is different from that of the petals.

Annual: lasting not above one year or one season, 83.

Annular: in the form of a ring.

Annular ducts, 46.

Annulate: marked with rings or circular transverse lines.

Annulus: the ring of the spore-case of true Ferns, 501, fig. 1289: that of the mouth of the spore-case or capsule of Mosses, 503, fig. 1304.

Anonacæ, 382.

Anophytes (top-growing plants, of the same meaning as *Acrogens*?), 370, 502.

Anteposition, 248.

Anterior: as to position in the flower, on the side next the bract, 237.

Anther: the pollen-bearing part of a stamen, 223, 281.

Antheridium (plural, *antheridia*), 334, 502.

Antheriferous: anther-bearing.

Anthesis: the time when the flower opens and performs its functions, or the act of expansion in a flower, 271.

Anthocérpous fruits, 318.

Anthocérôtæ, 504.

Anthodium: a technical name for the capitulum or head of flowers of a plant of the order Compositæ.

Anthôlysis: the retrograde metamorphosis of a flower.

Anthophore: the stalk or internode which is sometimes developed between the calyx and the corolla, as in Silene, 267, fig. 432.

Anticus: anterior, or facing forwards.

Antitropous, or antitropal: (reversed;) applied to the embryo, it means one with the radicle pointing away from the hilum, as in fig. 600 and fig. 606.

Antrorse: directed upwards or forwards.

Apétalous: destitute of petals or corolla, 260.

Aphyllous: destitute of leaves, at least in the form of foliage.

Apical: relating to the apex.

Apiculate: terminating in an abrupt short point or tip.

Apocérpous pistils: those not united into one body or compound pistil, 290.

Apocynacæ, 457.

Apôphysis: any irregular enlargement, like that of the spore-case of Splachnum and some other Mosses, 503.

Apothecium: the shield or shield-shaped fructification of most Lichens, 506.

Appendix, appendage: any superadded part.

- Appendiculate**: having an appendage.
Apple, 416.
Appressed: lying flat against, or close-pressed together.
Apricot, 417.
Apterous: wingless; having no dilated border or appendages.
Aquatic: living in water, either submersed or raised partly out of it.
Aquifoliaceæ, 442.
Araceæ, or **Aroidæ**, 485.
Arachnoid, or **drenose**: cobwebby, i. e. with entangled slender hairs looking like cobweb.
Araliaceæ, 427.
Arboreous, **arborescent**: tree-like, in size or appearance, 101.
Archegonium (pl. *archegonia*): the analogue in Mosses of the pistil.
Arcuate: curved like a bent bow.
Areola, pl. *areolæ*: spaces marked out on a surface.
Areolate: marked out into definite spaces.
Arhizal: destitute of root.
Aril, *arillus*: an accessory covering or appendage of a seed formed by a growth from the funiculus, hilum, or placenta after the completion of the ovule, 321, fig. 603.
Arillate: furnished with an arillus.
Arillode: a false aril, or covering of the seed appearing like an aril.
Aristate: furnished with an awn (*arista*).
Aristolochiaceæ, 462.
Arnatto, 392.
Arrêt: pointing upwards.
Arrowroot, 481, 490.
Arrow-shaped, or **arrow-headed**: see **Sagittate**; fig. 252.
Artichokes, 437.
Articulated: jointed, i. e. separating by an articulation or joint, as most leaves from the stem in autumn, or having the appearance of a joint, 92, 163, 173.
Artificial classification, 365, 511.
Artocarpeæ, 474.
Ascending: rising obliquely upwards, 102.
Ascending axis, 72, 91.
Asci: the spore-cases of certain Lichens and Fungi, 506, 507.
Ascidium: a pitcher-shaped or sac-shaped leaf, 169.
Asclepiadaceæ, 458.
Ashes of plants, 58, 174, 186.
Aspergilliform: shaped like an *aspergillus*, or brush used to sprinkle holy water, as the stigmas of most Grasses.
Assafœtida, 427.
Assimilation, 19, 21, 61, 177, 190.
Assurgent: same as ascending.
Atropous or **atropal** (ovules): same as orthotropous, 298.
Attar of Roses, 417.
Attenuate: tapering gradually to a thin or narrow extremity.
Augmentation of parts, 242.
Aurantiaceæ, 401.
Auriculate: eared; furnished with auricles or small lobes at the base.
Automatic movements, 347.
Ava, 469.
Avocado Pear, 467.
Awl-shaped: narrow and terete, or nearly so, and tapering to a point; 166.
Awn: a bristle-shaped appendage, like the beard of Barley, &c.
Awned: see **Aristate**.
Axil (*axilla*, the armpit): the angle between a leaf and the stem, on the upper side, 97.
Axile, or **axial**: belonging to the axis, 292.
Axillary: belonging to or growing in the axil.
Axillary buds, &c., 97, 210.
Axis: the stem and root, 67, 72; the central line of any body, as the *Axis of inflorescence*, 211.
Baccate: berry-like; of a fleshy or pulpy texture like a berry (*bacca*), 311.
Balm of Gilead, &c., 407.
Balsams, 145, 407, 414, 480.
Balsamiflora, 425.
Balsaminaceæ, 403.
Banner: same as vexillum, 253.
Barbate: bearded; bearing tufts, spots, or lines of hairs.
Barbellate: beset with short and stiff hairs, like the pappus of *Liatris spicata*, &c.
Barbellulate: a diminutive of the last.
Barberry, 384.
Bark, 120, 126.
Barley, 498.
Basal: belonging or relating to the base of an organ.
Basellaceæ, 464.
Basidia: cells of the fructification of Mushrooms, &c., which bear the spores, 507.
Basifixed: attached by the base.
Basilar: seated on the base of anything.
Bassorin, 55.
Bast, or **bass**, 400: *bast-cells* or tissue, 44, 120.
Baueriæ, 425.
Bayberry, 477.
Bdellium, 407.

- Beaked*: ending in a prolonged narrow tip.
- Bearded*: beset with hairs, especially stiff or long hairs. *Beard* is sometimes used for *awn*.
- Bell-shaped*: having the shape of a bell; 277, fig. 456.
- Benzoic Acid*, Benzoin, 443.
- Berberidaceæ*, 384.
- Bergamot*, 401.
- Berry*: a fruit fleshy or pulpy throughout, 311.
- Betel*, 469.
- Betulaceæ*, 477.
- Bi-* (or *bis*), as a prefix, means twice, as in the following:
- Biacuminate*: two-pointed.
- Biarticulate*: two-jointed.
- Biauriculate*: two-eared.
- Bibracteate*: with two bracts.
- Bibracteolate*: with two bractlets.
- Bicallous*: bearing two callosities or little protuberances.
- Bicipital*: having two stalks or legs, as the keel of a papilionaceous corolla, fig. 392.
- Biconjugate*: twice-paired, as when the petiole of a compound leaf forks twice.
- Bicornute*: two-horned.
- Bidentate*: having two teeth (not twice dentate or doubly toothed).
- Biennial*: lasting more than one year, but not more than two years, 83.
- Bifarious*: two-ranked; arranged in two vertical rows.
- Bifid*: two-cleft to the middle or thereabouts, 159.
- Biflorous*: two-flowered.
- Bifoliate*: two-leaved.
- Bifoliolate*: of two leaflets.
- Bifurcate*: two-forked, or, sometimes, twice-forked.
- Bigeminate*: twice-paired.
- Bigener*: a hybrid between two plants of different genera.
- Bignoniaceæ*, 447.
- Bijugate*: a pinnate leaf with two pairs of leaflets.
- Bilabiate*: two-lipped, 255, 258, 278.
- Bilamellate*, or *bilamellar*: of two plates or lamellæ.
- Bilberry*, 439.
- Bilobate*, or *bilobed*: two-lobed, 159.
- Bilocular*: two-celled.
- Binary*: the parts in twos, 239.
- Binate*: in twos; produced or borne in pairs, 164.
- Binomial nomenclature* (of two names), 363.
- Bipartite*: two-parted.
- Bipinnate*: doubly or twice pinnate; 164, fig. 282.
- Bipinnately*: twice pinnately, 161.
- Bipinnatifid*: doubly or twice pinnatifid; 161, fig. 280.
- Bipinnatisect*: twice-pinnately divided, 161.
- Biplicate*: twice folded, or having two folds.
- Biporose*: opening by two small holes or pores, fig. 474.
- Biradiate*: consisting of two rays.
- Birdlime*, 469.
- Birrinose*: opening by two slits, as do most anthers, fig. 473.
- Bisepate*: having two partitions.
- Bisérial*, or *bisériate*: occupying two rows, one within or above the other.
- Biserrate*: doubly serrate, i. e. the teeth themselves serrate.
- Bisexual*: having both stamens and pistils, 261.
- Bisulcate*: having two furrows.
- Biternate*: twice ternate; i. e. divided into three parts, and these again into three; 164, fig. 284.
- Blackberry*, 416.
- Bladdery*: thin and inflated, like a bladder.
- Blade* of a leaf, petal, &c., 145, 276.
- Bloom*, 56, 144.
- Blueberry*, 439.
- Boat-shaped*: concave within and convex (and often keeled) without.
- Bohon-Upas*, 475.
- Borraginaceæ*, 450.
- Bothrénchyma*, 45, 46.
- Brachiate*: with opposite branches, the successive pairs spreading at right angles with each other.
- Bract* (Latin, *bractea*): the leaves of an inflorescence, especially the leaf which subtends a flower, 143, 211.
- Bracteate*: subtended by a bract.
- Bracteolate*: subtended by
- Bractlets*, *bracteoles* (Latin, *bractéolæ*): bracts of a second order, &c., or bracts on the pedicel or the flower-stalk, 211.
- Branches*, and *branchlets*, 97.
- Brazil-wood*, 414.
- Bread-fruit*, 475.
- Breathing-pores*, 52, 150.
- Bristles*: stiff short hairs (52), or hair-like bodies.
- Bristly*: beset with stiff bristles.
- Bromeliaceæ*, 492.
- Bryology*: same as Muscology.
- Buckwheat*, 466.
- Bud*: a stem or branch in an undeveloped state, 93.
- Budding*, 100.
- Bud-scales*, 95, 167.
- Buffalo-berry*, 463.

- Bell**: a permanent bud with fleshy ovules usually subterminal. 368.
- Bell-shaped**: pertaining to buds.
- Bell-shaped**: like buds above ground. 368.
- Bell-shaped**: bell-like in shape.
- Bell-shaped**: same as a corn.
- Bell-shaped**: a surface appearing as if hollowed, perforated, or indented from below. a texture.
- Berberidaceae**. 494.
- Berberidaceae**. 494.
- Berberidaceae**: provided with pouch-like appendages. berberid.
- Berberidaceae**. 497.
- Berberid-shaped**: corolla. 253. 277.
- Berberid**. 476.
- Berberid**: composed of fine elongated threads. lignum, or fine flax.
- Berberidaceae**. 391.
- Berberidaceae**. 396.
- Berberid**. 421.
- Berberid**: falling off at the time of expansion, as the calyx of the Poppy. 273.
- Berberidaceae**. 413.
- Berberid**: lavender-colored.
- Berberid**: or capitate: growing in tufts or tufts.
- Berberid** (oil). 419.
- Berberid**. 447.
- Berberid-Nutmeg**. 383.
- Berberid**: a name for the head of Cornus.
- Berberid**: cup-shaped.
- Berberid**: bearing a spur (calcar), 278; as the Violet, fig. 396, and Larkspur, fig. 398.
- Berberid**, or calcariform, slipper-shaped.
- Berberidaceae**. 470.
- Berberid**: furnished with callosities (calli) or hardened or protuberant spots.
- Berberid**: bald.
- Berberidaceae**. 417.
- Berberid**: relating to the calyx.
- Berberid**, or calcarate: furnished with an outer accessory calyx (calculus), or set of bractlets resembling a calyx, as in Dianthus.
- Berberid**: the hood or veil of the spore-case of a Moss, 503, 504; or a body like it, 389.
- Berberid**: furnished with a calyptra, or something like it.
- Berberid**: shaped like a calyptra or candle-extinguisher, as the calyx of Eschscholtzia, p. 389, fig. 692.
- Berberid**: the exterior floral envelope, or leaves of the flower, 222, 274.
- Berberid**, Cambium-layer, 123.
- Berberidaceae**. 400.
- Berberidaceae**. 438.
- Berberid**: bell-shaped; 277, fig. 454.
- Berberid**. 494. 497.
- Berberid**: when a seed or seed-like fruit is rolled up so as to form a longitudinal furrow down one side, as that of Sweet Cicely.
- Berberid**: more or more elongated ovule or seed. 296. 298. fig. 327.
- Berberid**. 494.
- Berberid**: longitudinally channelled.
- Berberid**: presenting lattice-work.
- Berberid**. 477.
- Berberid**: widened or heavy with fine and close reticulation.
- Berberid**. 473.
- Berberid**. 494.
- Berberid**. 37. 452. 473. 475.
- Berberid**. 391.
- Berberid**: or capitate: hair-like.
- Berberid**: headed: having a globular apex like the head of a pin; or collected into a head.
- Berberid**: diminutive of capitate.
- Berberid**: a head of flowers, as of Clover. Burnon-bush, &c.; 213, fig. 320.
- Berberidaceae**. 391.
- Berberid**: furnished with tendrils.
- Berberidaceae**. 431.
- Berberid**: relating to a
- Berberid**: any compound dehiscent fruit; 315, fig. 582, 583.
- Berberid**. 490.
- Berberid**: a keel: the two anterior petals of a papilionaceous flower; 254, fig. 392. c.
- Berberid**: keeled: furnished with a projecting longitudinal ridge along the under side.
- Berberid**, or caryopsis: a grain, 314.
- Berberid**: flesh-colored.
- Berberid**: fleshy in texture.
- Berberid** (carpellum or carpidium): a simple pistil, or one of the elements of a compound one, 290.
- Berberid**: pertaining to a carpel.
- Berberid**: the department of Botany that relates to fruits.
- Berberid**: the stalk of a pistil, 267.
- Berberid**. 426.
- Berberid**: tough, like cartilage.
- Berberid**: an excrescence at the hilum of certain seeds, 322.
- Berberid**: furnished with a caruncle.
- Berberid**. 395.
- Berberid** (corolla): pink-like, 276.
- Berberid**: a grain, 314.
- Berberid**. 198.
- Berberid**. 406.
- Berberid**. 472.

- Cassia-bark, 467.
 Castor-oil, 472.
Castrate (stamen): with no anther or one containing no pollen.
Catapetalous: where the petals are united with each other at the base and with the base of the stamens, as in the Mallow family.
 Catechu, 414.
Caténulate: composed of parts united end to end, like the links of a chain.
Catkin: see Ament, 213.
Caudate: tailed or tail-pointed.
Caudex, 101.
Caudicle: a little stalk, like that of the pollen-mass of Orchis, &c., fig. 1235.
Caulescent: obviously having a stem.
Caulicle: a little stem, or a rudimentary stem; the radicle, 71.
Cauline, or *caulinar*: relating to a *Caulis*: the main stem, 91.
 Cayenne pepper, 456.
 Cedrelaceæ, 401.
 Cedron, 405.
 Celastraceæ, 408.
Cell: a cavity of an anther, ovary, &c., 281, 291. In vegetable anatomy, one of the vesicles, or elements of which a plant is composed, 23.
 Cell-formation, 27.
 Cell-growth, 30.
 Cell-multiplication, 28.
Cellular bark, or *envelope*, 121.
 Cellular Plants, 68.
Cellular tissue, or *structure*, 23.
Cellule: same as Cell (in veg. anatomy).
Cellulose, 27, 192.
 Celtideæ, 474.
Centrifugal inflorescence, 218.
 " radicle, 326.
Centripetal inflorescence, 212.
 " radicle, 326.
 Ceratophyllaceæ, 470.
Cereal: belonging to corn or corn-plants; these having been called the gift of Ceres.
Cernuous: nodding.
Chaff: the scales or bracts on the receptacle which subtend each a flower in the heads of many Compositæ, as the Sunflower; also the glumes, &c. of Grasses; 215, 435.
Chaffy: provided with, or of the texture of chaff.
Chalazæ: the part of the ovule where the coats, nucleus, &c. are all united; 298, fig. 521, d, 526, c.
Channelled: see Canaliculate.
 Characeæ, 510.
Characters: the essential marks distinguishing one species, genus, &c. from those most resembling it, 362.
Chartaceous: of the texture of paper or parchment.
 Checkerberry, 441.
 Chenopodiaceæ, 464.
 Cherry, 417.
 Chestnut, 477.
Chlorophyll: leaf-green, 58.
Chlorosis: a loss of color; a reversion of the petals, &c. of a blossom to green leaves.
 Chlorospermææ, 509.
 Chocolate, 398.
Chorisis: the division of one organ into two or more, 243.
Chromule: the coloring matter of plants, especially of petals, &c.
 Chrysobalanaceæ, 415.
Cicatrix: a scar left by the fall of a leaf or other organ.
Cilia (sing. *cilium*, the eyelash): hairs or bristles fringing the margin of anything; those of the inner peristome of a Moss, 502.
Ciliate: the margin fringed with hairs.
 Cinchona, 432.
 Cinchonæ, 432.
 Cinéchyra, 49.
Cinereous, *cineraceous*: ash-gray.
 Cinnamon, 467.
Circinate: involute from the top; 144, fig. 219.
 Circulation in cells, 31, 178.
Circumscissile, or *circumscissile*: opening or divided by a transverse circular line; 317, fig. 588.
Circumscription: the general outline.
Cirrhose, *cirrhiferous*: tendril-bearing, or with organs serving as a
Cirrus: a tendril.
 Cistaceæ, 393.
Cistoma: a kind of sac lining the chamber under a stomate in certain plants.
 Classes, 360.
 Classification, 352.
Clathrate: latticed.
Clavate, *claviform*: club-shaped; narrow below and thickened towards the summit.
Claviculate: with tendrils, or leafstalks acting as such (*claviculæ*).
Claw: the narrowed base of a petal, &c., 276.
Cleft: cut to about the middle, and with narrow or acute sinuses; 159, fig. 261, 265.
Climbing: rising by laying hold of other objects in any way, 102.
Clindanthium: the receptacle of the flowers in Compositæ.
 Cloves, 418.
Club-shaped: see Clavate.

- Cuscutum**, 438.
Cuspidate: collected into a bunch.
Cypripate: beak-shaped.
Cystostemate: twisted together.
Cystostemate: covering: united at the base or base.
Cylindrical, 343.
Cylindrical: growing together.
Cylindrical: crowded together.
Cylindrical: composed of layers; or furnished with a seed.
Cylindrical, or cylindrical: bearing long hairs like cobweb or grass.
Cycas *Indica*, 384.
Cycas (*pl. cycas*): anciently a berry; now used for the closed carpels into which many fruits split (316), as those of *Euphorbia*, fig. 1143, 1145, and *Verbena*, fig. 965.
Cylindrical: shaped like a spoon (cylindrical).
Cylindrical: like a mail-shell (cylindrical).
Cyrtopium, 415.
Cylindrical: i. e. hollow-ended; the top and bottom incurved, as in *Cyrtopium*-seed.
Cylindrical, 432.
Cylindrical: united together.
Cylindrical of parts, 250, &c.
Cylindrical (root-sheath): the sheath or covering (belonging to the cotyledon or plumule) through which the radicle of most Endogens bursts in germination.
Cylindrical, column: the neck or line of junction between the primary stem and root.
Collective fruits, 318.
Colocynth, 423.
Colored: of some other color than green.
Colombo-root, 384, 457.
Columnella: the axis, or central column, of a pod or spore-case.
Column: the united filaments of monadelphous stamens, or the united filaments and style in gynandrous flowers; 281, fig. 468.
Columnar: pillar-shaped.
Coma: a tuft of any sort, especially a tuft of hairs on a seed, 321, fig. 602; the whole head of a tree, &c.
Comate, or comose: bearing a coma.
Combretaceae, 419.
Commelinaceae, or Commelinaceae, 496.
Commisura: the line of junction of two carpels; used mostly in Umbelliferae, 426.
Common: used as "general," opposed to partial.
Complanate: flattened.
Complete flower: having all the kinds of organs, 222, 228.
Complete: folded upon itself.
Complete, 435.
Complete flower, 213, fig. 383-385, and 435, fig. 387, &c.
Compound leaf: one composed of two or more blades, 163.
Compound part, 294.
Compound vein, raceme, umbel, &c., 216.
Compound: flattened on two opposite sides.
Compound layers of wood, 112, 122.
Conchiform: shell-shaped.
Concolor: all of one color.
Concolorate: folded together lengthwise, 144, 165.
Concolor: see *Strobile*, 319.
Concolorate: stuck together by their adjacent faces, as the cotyledons of *Hieracium*, 327.
Concolor: crowded.
Concolor: running together, or blended into one.
Concolor: similar to; or closely fitted to, as the skin to the kernel of a seed.
Concolor: crowded together.
Concolor: clustered into a ball.
Concolorate: thickly clustered.
Concolor, 479.
Concolor: cone-bearing.
Concolor: coupled; in single pairs.
Concoloration, 332.
Concolor: united or grown together from the earliest stage, 251.
Concolor-perforate, 168, fig. 294.
Concolor, connectivum: the part of the anther connecting its two cells or lobes, 281, 282.
Concolor: converging.
Concolor: approaching a conical form.
Concolorate: when unlike parts are grown together.
Concoloration, 250.
Concolor: not interrupted.
Concolor: twisted, 272.
Concoloruplicate: twisted and folded.
Concolor: either narrowed or shortened.
Concolor: opposite in direction to something it is compared with, as the pod of Shepherd's Purse flattened contrary to the partition.
Concolorate (rolled up) or *concolorate* invagination, 272.
Concolorate veneration: rolled up lengthwise in the bud, 144.
Concolorulaceae, 454.
Copaiva, 414.
Copal, 414.
Copalche-bark, 434.
Cordate: heart-shaped; shaped like a heart as painted upon cards, the

- sinus, or notched end, being at the base; fig. 244.
- Cordiacæ**, 451.
- Coriaceous**: of a leathery consistence.
- Cork**, 477.
- Corky**: of the texture of cork.
- Corky envelope or layer of the bark**, 121, 127.
- Corn (cornus)**: a solid bulb, 108.
- Cormophytes**: plants having an axis (root and stem), in contradistinction to *Thallophytes*, 371.
- Cornaceæ**, 428.
- Corneous**: of the consistence of horn.
- Corniculate**: furnished with a small horn.
- Cornine**, 428.
- Cornute**: furnished with a horn (*cornu*).
- Corolla**: the inner of the two floral envelopes, 222, 275.
- Corollaceous, corolline**: like a corolla in appearance or texture, or belonging to the corolla.
- Coróna**: a crown; such as the appendage at the top of the claw of the petals of *Silene*; 246, fig. 378.
- Coronate**: bearing a crown.
- Cortex**: the bark or rind.
- Cortical**: pertaining to the bark.
- Corticæ**: furnished with a distinct rind.
- Corymb**: a convex or flat-topped flower-cluster, 211.
- Corymbose**: disposed in, or resembling, corymbs.
- Costa**: a rib, or midrib.
- Costate**: ribbed, or with a midrib.
- Cotton**, 44, 398.
- Cotyledons**: the first leaves of the embryo; seed-leaves, 71, 324.
- Cotyliform**: dish-shaped.
- Coumarin**, 414.
- Cowitch**, 415.
- Cranberry**, 439.
- Crassulacæ**, 423.
- Crateriform**: goblet-shaped.
- Creeping**: running on or beneath the ground and rooting, 102.
- Crénocarp**: the fruit of *Umbelliferæ*, 425.
- Crenate, or crenelled**: the margin furnished with even and rounded notches or scallops; 159, fig. 256.
- Crénulate**: diminutive of *Crenate*.
- Crescenticæ**, 447.
- Crested**: see *Cristate*.
- Cribose**: pierced with holes like a sieve.
- Crimite**: bearded with long hairs.
- Crispate**: curled.
- Cristate**: crested; bearing any elevated appendage on its surface.
- Cross-breeds**: individuals originated by fertilizing one variety or species by another, 356, 357.
- Crowberry**, 474.
- Crown (246, 279, fig. 378)**: see *Corona*.
- Crowned**: see *Coronate*.
- Crowning**: borne on the apex of any organ.
- Cruciate, or cruciform**: cross-shaped, 277, as the corolla of the Mustard family, fig. 405.
- Cruciferae**, 389.
- Crude sap**, 53, 190.
- Crustaceous**: crusty in texture, hard and brittle.
- Cryptogamia**, 513.
- Cryptogamous or cryptogamic**: relating to
- Cryptogamous Plants**, 69, 330, 499.
- Crystals**, 59.
- Cucullate, or cuculliform**: hooded or hood-shaped; rolled up like a corner of paper, 503.
- Cucumber**, 423.
- Cucurbitacæ**, 423.
- Culm**: a straw, or straw-like stem, 101.
- Cultrate**: shaped like a broad knife-blade.
- Cuneate, or cuneiform**: wedge-shaped; broad above, and narrowed to the base, with straight sides; fig. 235.
- Cunoniaceæ, or Cunoniæ**, 525.
- Cupressineæ**, 480.
- Cup-shaped, cupuliform**: hemispherical, and hollow above.
- Cupulate**: furnished with a
- Cupule, or cupula**: the acorn-cup, 314.
- Cupuliferæ**, 476.
- Curled**: irregularly folded and crimped.
- Currant**, 421.
- Curvilinear**, 158, fig. 236.
- Curviserial**: in curved ranks, 141.
- Cuscutæ, or Cuscutineæ**, 455.
- Cushion**: the swollen base of a leaf-stalk, or the enlargement below the insertion of many leaves.
- Cuspidate**: tipped with a *cusp*, or sharp and rigid point; 162, fig. 275.
- Custard-Apple**, 382.
- Cut**: see *Incised*, or *Dissected*.
- Cuticle**: the outer skin or pellicle of the epidermis, 149.
- Cyathiform**: cup-shaped.
- Cycadacæ**, 481.
- Cycle**: one complete turn of a spire; a circle.
- Cylindrical**: coiled into a full circle.
- Cyclôsis**: circulation in cells, 31.
- Cylindraceous**: approaching to the
- Cylindrical**: circular in transverse outline and tapering gradually, if at all, as in most stems.
- Cymbæform**: boat-shaped.

- Cyme (cyma)*: a cluster of centrifugal inflorescences, 218.
Cynose: bearing cyines, or cyme-like.
Cynule (cynula): a *cymulet*, or little cyme, 218.
Cynarrhodium: such a fruit as that of Rose (fig. 429) and *Calycanthus*, fig. 815, 819.
Cyperaceæ, 496.
Cypselæ: an achenium with an adherent calyx-tube, as in *Compositæ*.
Cystidium: a utricle.
Cystolithes, 60.
Cytoblast: the nucleus of a vegetable cell.
- Dammer Pitch**, 400.
Deca-, in words of Greek derivation: ten; as in
Decagynia, 515.
Decagynous: with ten pistils or styles.
Decidnerous: the parts in tens, 234.
Decandria, 512.
Decandrous: with ten stamens, 280.
Decapetalous: with ten petals, 276.
Deciduous: falling off, or subject to fall; as petals falling after blossoming, 279, and leaves before winter, 172.
Declinate, declined: turned to one side.
Decomposed: several times compounded, 165.
Decumbent: reclined on the ground, the summit rising, 102.
Decurrent: prolonged below the insertion, as the leaves of the Thistle, 170.
Decussate: the successive pairs crossing each other at right angles, 142.
Deduplication (dédoulement), 243.
Definite: of a fixed number, and not above twelve or twenty.
Definite growth, 100.
Definite inflorescence, 217.
Deflexed: bent downwards.
Deflurate: past the flowering state.
Defoliate: having cast its leaves.
Dehiscent fruits, &c., 315; opening by
Dehiscence: splitting, as do pods, 311, 316.
 " of anthers, 283.
Deliquescent: the stem dissolving into branches, 99.
Deltoïd: shaped like the Greek capital Δ .
Demersed: growing under water.
Dendroid, dendritic: tree-like.
Dentate: same as toothed; 159, fig. 255.
Denticulate: furnished with fine teeth, or denticulations.
Denudate: made naked.
Depauperate: dwarfed in size.
Depressed: flattened vertically or from above.
- Descending*: tending gradually downwards.
Descending axis, 72, 79.
Desmidiæ, or *Desmidiaceæ*, 510.
Determinate inflorescence, 217.
Descriptive Botany, 15.
Development, 19.
Dextrine, 54, 193.
Dextrorse: towards the right.
Di-, in Greek compounds; two.
Diadelphia, 513.
Dialéphous: stamens united by their filaments in two sets; 280, fig. 461.
Diandria, 512.
Didndrous: with two stamens, 279.
Diagnosis: a brief essential character.
Diulypetalous: of distinct petals.
Diapensiaceæ, 454.
Didphanous: transparent.
Diatomaceæ, 510.
Dicarpellary: of two carpels.
Dichamydeous: with both calyx and corolla.
Dichondrææ, 455.
Dichotomous: forking into two branches.
Dichinous: with the stamens and pistils in separate blossoms, 261.
Dicocceous: separable into two cocci.
Dicotylédonous: having a pair of cotyledons, 78, 326.
Dicotyledons, Dicotyledonous Plants, 114, 326, 370.
Didymous: twin.
Didynámia, 512.
Didynamous: with two long and two shorter stamens, 258, 281.
Difformed: of unusual shape.
Diffuse: widely and loosely spreading.
Digamous: having flowers of two different sexes.
Digestion, 190.
Digitate (fingered): compound, with the parts all arising from the same point; 163, fig. 277.
Digitately tri-plurifoliate, 164.
Digynia, 515.
Digynous: with two pistils or styles, 287.
Dilleniaceæ, 380.
Dimerous: the parts in twos, 234, 239.
Dimidiate: halved, or appearing as if one half or side were wanting, 283.
Dimorphous: of two forms.
Dieceia, 513.
Diceious: with stamens and pistils in separate blossoms on different individuals, 262.
Dioscoreaceæ, 492.
Diosmeæ, 407.
Dipetalous: of two petals, 276.
Diphyllous: two-leaved, 275.
Diplostemonous: stamens double the petals or sepals in number.

- Dipsacæ*, 435.
Dipterocarpeæ, 400.
Dipterous: two-winged.
Disciform: disk-shape; flat and circular, like a disk or quoit.
Discoidal, discoid: like a disk; or belonging to the disk; destitute of rays, 436.
Disepalous: of two sepals.
Disk, or *disc*: a fleshy expansion of the receptacle of a flower, 267: the central part of a head of flowers, as opposed to the border, 436; the face of any flat body, as opposed to the margins.
Disk-bearing woody tissue, 43.
Disk-flowers, 436.
Dissected: cut into pieces, or nearly so.
Dissepiment: the partition of a pod, 291.
Dissilient: bursting in pieces.
Distichous: in two vertical ranks, 134.
Distinct: when parts of the same name are unconnected, 251.
Divérécate: straddling widely.
Divergent: separating, their summits inclining from each other.
Divided: cut into distinct portions; 160, fig. 263, 267.
Dodeca-: in Greek derivatives; twelve.
Dodecagynia, 515.
Dodecagynous: with twelve pistils or styles.
Dodecandria, 512.
Dodecandrous: with twelve (or from twelve to nineteen) stamens, 280.
Doldbriform: axe-shaped.
Dorsal: belonging to the back (*dorsum*).
Dorsal suture, 289.
Dotted ducts, 38.
Dotted leaves, &c.: marked with small spots, either colored, or transparent and appearing like punctures.
Double flowers: monstrous blossoms, with the petals unduly multiplied, 222, 229.
Doubly compound, 164.
Downy: clothed with soft pubescence.
Dragon's blood, 414, 493.
Droseracæ, 394.
Drupaceous: like or pertaining to a drupe.
Drupe: a stone-fruit, 312.
Drupelet: a diminutive drupe, 313.
Dryadæ, 418.
Ducts, 45.
Dumose: bushy.
Duplicate: doubled or folded.
Duramen: heart-wood, 126.
Dwarf: comparatively low in stature.
E-, or Ex-, as a prefix, means destitute of; as, *ecostate*, ribless; *exalbuminous*, without albumen, &c.
Eared: see *Anriculate*.
Earthy constituents of plants, 179, 186.
Ebenacæ, 442.
Ebénous: black like ebony.
Ebony, 442.
Ebracteate: destitute of bracts.
Ebracteolate: destitute of bractlets.
Ebérneous: white like ivory.
Echinate: beset with prickles (like a hedgehog).
Echinulate: rough with small prickles.
Edentate: toothless.
Effete: past the perfect or productive state.
Effuse: very loosely spreading.
Eglandulose: destitute of glands.
Elaborated sap, 53.
Elæagnacæ, 467.
Elaters, 40, 505.
Elatinacæ, 395.
Elementary constituents of plants, 179.
Elementary structure of plants, 17.
Ellipsoidal: approaching the form of
Elliptical: oval or oblong, and with both ends similar and regularly rounded.
Emarginate: notched at the end; 162, fig. 273.
Embracing: surrounding, as by a broad attachment.
Embryo: the rudimentary plantlet in a seed, 71, 323.
Embryo-sac, 304.
Embryogeny: the formation of the embryo, 304.
Embryonal vesicle, 306.
Emersed: raised out of water.
Emetine, 433.
Enantioblastous: with the embryo at the end of the (orthotropous) seed diametrically opposite the hilum, as in *Tradescantia*.
Endecagynia, 515.
Endecagynous: with eleven pistils or styles.
Endocarp: the inner layer of a pericarp, 310, 312.
Endochrome: the coloring matter of *Algæ*.
Endogen, Endogénæ, Endogenous Plants, 113, 370, 482.
Endogenous structure, 113, 114.
Endophléum: inner bark, 120.
Endopleura: the innermost seed-coat, 321.
Endorhizæ: a synonyme for *Endogens*.
Endorhizal: said of an embryo which has the radicle sheathed by the cotyledon or plumule wrapped around it.
Endosmose, or Endosmôsis, 33.
Endosperm: the albumen of the seed,

- especially when this informed it the embryo-out of the ovule, 322, 323.
- Endosperm*: the orifice of the inner coat of the ovule, 296.
- Endothecium*: the inner lining of the oris of an anther.
- Enervol*: enervol.
- Enam*: same; as in
- Enamycin*, 515.
- Enanthropus*: with nine pistils or styles.
- Enanthropus*, 512.
- Enanthropus*: with nine stamens.
- Enanthropus*: nine-petalled, 276.
- Enanth*: without a node.
- Enanth*: same as
- Enanth*: sword-shaped.
- Entire*: the margin whole and even, not toothed or cut, 158, 275.
- Entophytes*: plants parasitic within other plants.
- Epacridae*, 440.
- Ephemeral*: lasting but a day.
- Epi*, in Greek compounds: upon.
- Epicalyx*: an involucre resembling an exterior calyx, as in Malvaceae.
- Epicalyx*: the outermost layer of a pericarp, 310.
- Epichilium*: the upper part of the lip of an Orchid, when different from the lower.
- Epichilium*: upon the corolla.
- Epidermal*: relating to the
- Epidermis*: the skin of a plant; 51, 122, 148.
- Epigamous*: growing on or close to the ground.
- Epigynous*: upon the ovary, 252, 268, 281.
- Epipetalous*: upon the corolla, 281.
- Epiphloema*: outer or corky bark, 121.
- Epiphyllous*: upon a leaf.
- Epiphyllal*, or *epiphytic*: relating to
- Epiphytes*, plants growing affixed to another plant, but not nourished by it, 87.
- Epipetrous*: winged at the top.
- Episperm*: the outer seed-coat, 320.
- Equal*: regular, or of the same length or number, as the case may be.
- Equilateral*: equal-sided.
- Equisetaceae*, 499.
- Equilant*: riding straddle, 145, 165.
- Erianthous*: woolly-flowered.
- Ericaceae*, 439.
- Ergot*, 498.
- Eriocaulonaceae*, 496.
- Eriogonaceae*, 466.
- Erose*: eroded, as if gnawed.
- Erostrate*: not beaked.
- Escalloniaceae*, 425.
- Essential organs of the flower*, 222.
- Estivation*: see *Restivation*.
- Estris*: a name for such a fruit as a raspberry and blackberry.
- Eupharisacae*, 471.
- Eusimul*, or *eusimul*: univocal.
- Eusimul*: heading the leaves over winter or longer, 172.
- Eusimul*: without a stem, 222.
- Eusimul*: out of the center, 215; enclosed.
- Excisions*, 57, 178.
- Excision*: protruding beyond the apex, as when the middle of a leaf projects: or running to the very summit, as the main stem of a Fir, 99.
- Excision*, 173.
- Excision*: the outer layer of a pericarp, 312.
- Exogon*, *Exogon*, *Exogon*, *Exogon*, 113, 376.
- Exogon* structure, 113, 116.
- Exorhiza*: a synonyme of *Exogon*; the radicle in these being
- Exorhiza*: not enclosed or sheathed by the cotyledons or plumule.
- Exorhiza*, or *Exorhiza*, 33.
- Exorhiza*: the orifice of the outer coat of an ovule, 298.
- Exorhiza*: an indurated protuberance.
- Exorhiza*: outer coat of the anther.
- Exorhiza*: outspread or broadly flattened.
- Exorhiza*, *exert*: protruding beyond, as the stamens out of the corolla in fig. 450.
- Exorhiza*: destitute of stipules, 171.
- Exterior*: as applied to the parts of a blossom, the same as *anterior*.
- Extine*: the outer coat of a pollen-grain, 286.
- Extra-axillary*: out of the axil, 99, 220.
- Extorve*: turned outwards, 282.
- Facies*: the general aspect.
- Falcate*, *falciform*: scythe-shaped; flat and curved, the edges parallel.
- Families*, 359.
- Fan-shaped*: see *Flabelliform*.
- Farina*: starch, 54.
- Farinaceous*: mealy; containing starch.
- Farinose*: covered with mealy powder.
- Fasciatis*: banded; applied also to monstrous stems which grow flat.
- Fasciation*: the singular monstrous expansion of stems, &c. as in the garden Cock's-comb.
- Fascicle*: a close cyme or cluster of flowers, 219; a bundle of leaves crowded like those of the Larch, fig. 213.
- Fascicled*: growing in tufts or clusters, 84, 142.

- Fasciculate*: in small tufts.
Fastigiate: close, parallel, and upright.
Faux (pl. *fauxes*): the gorge or throat.
Fæveolate, fævose: with deep pits, like honeycomb.
Feather-veined: having veins all proceeding from a midrib, 155.
Feathery: see plumose.
Fécula: starch, 54.
Female flower: see Fertile flower.
Fenêstrate: pierced with one or more holes, like windows.
Ferrugineous or ferruginous: of the color of iron-rust.
Fertile: capable of producing fruit. Stamens are also said to be fertile when their anthers contain good pollen.
Fertile flower: one having pistils, 261.
Fertilization, 300.
Fibre, 41.
Fibril: a delicate fibre-like body; the root-hairs, 81.
Fibrilliform tissue, 48.
Fibrillose: bearing fibrils: diminutive of fibrous.
Fibrine, 198.
Fibrous or fibrose: composed of slender threads or fibres.
Fibro-vascular tissue or system, 50.
Fiddle-shaped: obovate and contracted on each side.
Fig, 215, 475, and fig. 590-592.
Filament: the stalk of an anther, 223, 281. Or any slender thread.
Filamentous, or filamentose: composed of threads or filaments.
Filices (Ferns), 500.
Filicology: the part of Botany which treats of Ferns.
Filiform: shaped like a thread; slender and terete, 166.
Filipendulous: hanging from a thread, as the tuberos roots of *Spiræa filipendula*.
Fimbriate: fringed; bordered by slender processes or appendages.
Fimbrillate or fimbrilliferous: diminutive of the last.
Fingered: see Digitate.
Fissiparous: propagating by division into two portions.
Fistular or Fistulose: hollow through its length, as the leaves of Onion.
Fidbellate, or flobelliform: fan-shaped; broadly wedge-shaped with the summit rounded.
Flacourtiaceæ, 392.
Flagellate: bearing *flagella*, i. e. runners, like those of the Strawberry.
Flagelliform: long, taper, and supple, like the thong of a whip; runner-like.
Flavescent: yellowish or pale yellow.
Flavous: yellow.
Flax, 402.
Fleshy: succulent, or of the consistence of flesh, 84.
Flexuose, or flexuous: zigzag; bent alternately inwards and outwards.
Floating: growing on the surface of water.
Floccose: bearing or clothed with locks of soft hairs or wool.
Flora (the goddess of flowers): the aggregate of the species of plants of a country; or a work systematically describing them.
Floral: belonging to the flower.
Floral envelopes: flower-leaves, 222, 268.
Florescence: same as anthesis.
Floret: a small flower, or a separate blossom of a so-called compound flower.
Floridææ, 509.
Floriferous: flower-bearing.
Flosculous: composed of or bearing *flosculi*, i. e. florets; or composed of tubular flowers only.
Flower, 70, 221.
Flower-bud, 209, 224.
Flowering, 204.
Flowering Plants, 69, 369, 375.
Flowerless Plants, 69, 330, 499.
Fluitant: floating on water.
Fluviatile: belonging to flowing water.
Fly-traps, 168.
Foliaceous: leaf-like, i. e. thin, membranaceous and green; or bearing leaves.
Foliar: belonging to leaves (*folia*).
Foliation: leafing out.
Foliate: clothed with leaves; or, with a numeral prefix, denoting the number of leaves; as, *bifoliate*, two-leaved: *trifoliate*, three-leaved, &c.
Foliolate: consisting of leaflets (*foliola*); as, *bifoliate*, a leaf having two leaflets, or *trifoliate*, having three leaflets, &c.
Foliose: bearing numerous leaves.
Follicle: a simple pod opening down one side; 315, fig. 579.
Follicular, of the nature of a follicle.
Forâmen: an aperture or orifice, 298.
Foraminulose: pierced with small holes.
Forcinate: forked like a pair of pincers.
Forked: branching into two or more divisions.
Fornicate: arched over, bearing a
Fornix, pl. *fornices*: little arched scales in the throat of a corolla, as in that of Hound's-tongue.

- Glandular woody tissue*, 43.
Glareous: growing in gravelly places.
Glaucous: verging upon or slightly
Glaucous: covered with a whitish bloom,
 which rubs off, as the surface of a
 cabbage-leaf or a plum, or so
 whitened as to appear to have a
 bloom, 56.
Globose: spherical or nearly so.
Globular: nearly globose or spheri-
 cal.
Glochideous, or *glochidiate*: barbed;
 hooked back at the point, like the
 barb of a fish-hook, or with two or
 more such barbs at the point.
Glomerate: clustered into a
Glomerule: a capitate cyme, i.e. a cyme
 condensed into a head, 219.
Glossology: the department of Botany
 which explains the technical terms
 of the science, 15.
Glumaceous: bearing, or resembling
 glumes.
Glume: one of the husks or chaff of
 Grasses, &c., 497.
Glumelle: an inner glume or *palea*.
 Gluten, 197.
 Glutine, 198.
Gonophore: a stalk elevating both sta-
 mens and pistil, 267.
 Gooseberry, 421.
Gossypine: cottony.
Gourd (a pepo), 423.
 Grafting, 100.
 Grain, 314.
 Gramineæ, 497.
 Granadilla, 422.
Granular: composed of grains or gran-
 ules.
Granulate: composed of little kernels
 or coarse grains.
Granules: any minute particles.
 Grape, 408.
Green layer of the bark, 121.
 Grossulacæ, 420.
Grumous, or *grumose*: consisting of
 clustered grains.
 Guaiacum, 405.
 Guava, 418.
 Gum Animi, 400. Gum Arabic, 414.
 Gum Elemi, 407. Gum Traga-
 canth and Senegal, 414.
 Gutta-percha, 57.
Guttate: sprinkled with colored dots or
 small spots.
 Guttiferæ, 400.
Gynnocarpous: naked-fruited.
 Gymnospermia, 315.
Gymnospermous: naked-seeded, 296.
 Gymnosperms, or Gymnospermous
 Plants, 297, 371, 479.
Gynæcium: the pistils of a flower, 223.
 Gynandria, 513
Gynandrous: stamens borne on the pis-
 til, especially on the style; 253,
 281, fig. 468.
Gynobase: the base of a style, or sum-
 mit of a receptacle, on or around
 which two or more carpels are in-
 serted, as in Rue, Sage, Geranium,
 &c., 267.
Gynophore: the stalk of a pistil, 267.
Gyrate or *gyrose*: bent round, or bent
 back and forth.
Habit (*Habitus*): the general aspect of
 a plant.
Habitat: the habitation, or situation in
 which a plant is naturally found.
 Hackberry, 474.
 Hæmatine, 414.
 Hæmodoracæ, 492.
 Hairs, 52.
Hairy: clothed or beset with hairs,
 which are separately distinguish-
 able.
Halberd-shaped, or *Halberd-headed*: see
 Hastate.
 Haloragcæ, 420.
Halved: see Dimidiate; appearing as if
 one half was absent.
 Hamamelacæ, 425.
Hamate, or *hamose*: hooked.
Hannulose: diminutive of hamate.
Hastate: halberd-headed, shaped like
 a halberd, viz. with a spreading
 lobe at the base on each side; 157,
 fig. 250.
 Hazel-nut, 476.
Head: see Capitulum; 213, fig.
 320, &c.
Headed: same as capitato.
Heart-shaped: see Cordate.
Heart-wood, 35, 124, 126.
Hebetate: blunted, having a soft obtuse
 point.
Helicoid: coiled into a helix or snail-
 shell, or tending to be rolled up;
 as in Fig. 332.
Helmet: see Galea, 278.
Helobious: living in marshes.
Helvicolous: grayish-yellow mixed with
 some red.
Hemi- in Greek derivatives: halved or
 half; as
Hemi-andropous: half-anatropous.
Hemicarp: a half-fruit of Umbelliferæ;
 same as mericarp.
Hemistropal, or *hemitropous*: nearly the
 same as amphitropous.
 Hemp, 475.
 Hepaticæ, 503.
Hepta: the Greek numeral seven, used
 in the following compounds.

Heptagýnia, 515.

Heptágynous: having seven pistils or styles.

Heptámerous: the parts in sevens.

Heptandria, 512.

Heptándrous: with seven stamens, 280.

Heptapétalous: of seven petals, 276.

Herb, 101.

Herbaceous: not woody; of a soft texture like an herb, 101, 102.

Herbarium: the botanist's collection of dried specimens of plants, 518.

Hermáphrodite: bisexual, 261.

Hesperidium: a firm-rinded berry like an orange, 311.

Hetero-, in Greek derivatives: unlike; as *Heterocárpous*: having two kinds of fruit.

Heterocéphalous: bearing two kinds of heads; as in *Baccharis*.

Heterodrómous, 140.

Heterógamous: bearing two sorts of flowers, 436.

Heterogeneous: of two or more kinds.

Heterótrous, or *heterótrous*, ovule or seed: same as amphitropous, 300.

Hera-, in Greek derivatives; six.

Hexagýnia, 515.

Hexágynous: having six pistils or styles.

Hexámerous: the parts in sixes, 234.

Hexandria, 512.

Hexándrous: with six stamens, 279.

Hexapétalous: six-petalled, 276.

Hexaphýllous: six-leaved, 275.

Hexápteros: six-winged.

Hexasépalous: with six sepals, 272.

Hexastémonous: having six stamens.

Hickory-nut, 476.

Hidden-veined: where the veins are not visible, as those of the leaves of Pinks and Houseleeks.

Hilar: relating to the hilum.

Hilum: the scar, or point of attachment of the seed, 297, 321.

Hippocastanaceæ, or *Hippocastanææ*, 410.

Hippocrépiform: horseshoe-shaped.

Hirsute: clothed with coarse hairs.

Hispid: beset with stiff bristly hairs.

Hoary: grayish-white from a fine pubescence.

Homocarpous: bearing fruits all of one kind.

Homodrómous, or *homodromal*, 140.

Homógamous: when all the flowers of a head, &c. are alike, 436.

Homogeneous: all of the same nature or structure.

Homologous: of the same name; said of parts which are of the same morphological nature; e.g. bracts, sepals, petals, stamens, and sim-

ple pistils are homologous with leaves; 225, 231. See Analogous.

Homologue: an homologous part.

Homómallous (leaves, &c.): originating all round an organ, but directed or curved round to one side of it.

Homomórhous: of one form.

Homótrous, or *homotropical* (embryo): curved in the same way as the seed, as in the Chickweed, fig. 621.

Hops, 475.

Horny: see Corneous.

Horizontal system, 50, 112.

Hortus Siccus: same as herbarium.

Huckleberry, 439.

Humifuse: spreading flat on the ground.

Humus, Humic acid, 57.

Hyaline: transparent, or partly so.

Hybrid: a cross-breed between individuals of two species, 357.

Hydrangieæ, 425.

Hydrocharidaceæ, 487.

Hydroleaceæ, or Hydroleæ, 452.

Hydrophyllaceæ, 451.

Hydrophyte: a water-plant.

Hydropterides, 502.

Hymal: belonging to winter.

Hyménium: the gills of Mushrooms, &c., 507.

Hymenophyllæ, 501.

Hypánthium: a naked fleshy receptacle, like a fig.

Hypericaceæ, 394.

Hypo-, in Greek derivatives: under.

Hypochílium: the under part of the lip of Orchids, when jointed or otherwise distinguishable.

Hypocráteri-form, or, more properly,

Hypocraterimórhous: salver-shaped; i. e. with a limb spreading flat at right angles to the tube; 277, fig. 457.

Hypogæous, or *hypogæan* (flowers or fruits): borne under ground, 76, 78, 328.

Hypógynous: growing under the pistil, and free, 250, 268, 280.

Hypophýllous: growing on the lower side of a leaf.

Hysteranthous: plants whose leaves appear later than the blossoms, as the Red Maple.

Hysterophytal: living on a matrix, either of dead or living organic matter.

Hysterophytes: same as Fungi, &c.

Icos-, in Greek compounds: twenty.

Icosandria, 512.

Icosándrous: having 20 stamens or more inserted on the calyx, 280.

Illecebrææ, 396.

Imbibition, 177.

- Imbricate, imbricated, imbricative*: overlapping, the outer covering the inner, and breaking joints, like tiles on a roof, 144, 269.
- Immarginate*: not margined.
- Immersed*: growing wholly under water.
- Impari-pinnate*: pinnate with an odd leaflet; 163, fig. 288.
- Imperfect flowers*: wanting either stamens or pistils.
- Impregnation*: same as fertilization.
- Inane*: empty.
- Incaneous*: hoary-white.
- Incised*: cut irregularly and sharply; 159, fig. 259.
- Included*: not projecting beyond; enclosed.
- Incomplete flower*: wanting some one or more kinds of organs, 259.
- Incrassated*: thickened.
- Incrustations in cells*, 58.
- Incubous*: the apex of each leaf lying over the base of the next, as in many Hepaticæ.
- Incumbent*: leaning or lying upon: said of the cotyledons when the radicle lays against the back of one of them, 390, 326, fig. 705; or when the anther lies on the inner side of the filament, 282.
- Incurved*: bent or curved inwards.
- Indefinite*: either uncertain in number, or too many to be readily counted, 242.
- Indefinite growth*, 100.
- Indefinite inflorescence*, 210.
- Indehiscent* (fruits): not opening, at least not in a regular way, 310, 313.
- Indeterminate inflorescence*, 210.
- India-rubber*, 57.
- Indigenous*: of spontaneous and original growth in a country.
- Indigo*, 414, 415.
- Individual*, 20, 131, 352.
- Individuality*, 132, 352.
- Indumentum*: any hairiness or downy covering.
- Induplicate*: bent or folded inwards, 145, 273.
- Indusium*: the proper covering of the fruit-dots of Ferns; any peculiar membranous covering, 501.
- Inequilateral*: unequal-sided.
- Inferior*: underneath, 252; or same as anterior: thus the inferior petal, &c. is the same as the anterior one, 237.
- Inflated*: bladdery.
- Inflexed*: abruptly bent inwards.
- Inflorescence*, 209.
- Infra-axillary*: originating below the axil.
- Infundibular, infundibuliform*: funnel-shaped; i. e. a tube enlarging upwards; 277, fig. 1049.
- Innate*: borne directly on the apex of a thing, 282.
- Innovations*: new shoots or new growths.
- Inorganic*: unorganized.
- Inorganic constituents*, 179.
- Inosculating*: opening into each other; anastomosing, 49.
- Inserted*: attached to, 224, 250.
- Insertion*: the place or the mode of junction of leaves with the stem, &c., 133.
- Inter*, in composition: between; as
- Intercellular*: between the cells.
- Intercellular spaces or passages*, 24, 50.
- Intercellular system*, 50.
- Interlaced tissue*, 48.
- Internal glands*, 51.
- Internodes*, 92.
- Interpetiolar*: between the petioles, 171.
- Interruptedly pinnate*, 164, fig. 285.
- Intine*: the inner coat of a pollen-grain.
- Intrafoliaceous*: within or before a leaf, 171, as the stipules in fig. 305.
- Introflexed*: bent strongly inwards.
- Introrse*: turned inwards towards the axis, 282.
- Intruse*: appearing as if pushed inwards or indented.
- Inverse*: inverted; suspended.
- Involucellate*: furnished with an
- Involucellum, or involucl*: a secondary or partial involucre, 216.
- Involucrate*: provided with an
- Involucrum, or involucre*: an outer or accessory covering; a set of bracts surrounding a flower-cluster; 214, fig. 321, &c.
- Involute*: rolled inwards, 144, 273.
- Ipecacuanha*, 393, 433.
- Iridaceæ*, 490.
- Irregular*: unequal in size or in shape, 253, 277.
- Irregularity*, 253.
- Irritability*, 345.
- Isôchroûs*: one-colored.
- Isoëtineæ*, 502.
- Isômeros, or isômeric*: the parts equal in number.
- Isostemonous*: the stamens as many as the petals or sepals.
- Jalap*, 455.
- Jasminaceæ*, 459.
- Jelly*, 55, 310.
- Jointed*: separate or separable transversely into pieces (joints), 92.
- Juba*: a loose panicle, as of Grasses.
- Juga*: the ridges of the fruit of Umbellifera, 426.

- Jugæ*: the pairs of partial petioles or leaflets of a pinnately-compound leaf, 164.
- Juglandaceæ*, 476.
- Jujube*, 408.
- Julus*: a name for a catkin.
- Julaceous*: shaped like or resembling a catkin.
- Juncaceæ*, 495.
- Juncagineæ*, 487.
- Jungermanniaceæ*, 505.
- Juniper-berries*, 480.
- Jute*, 400.
- Keel*: see *Carina*, 254.
- Keeled*: furnished with a keel or sharp ridge underneath.
- Kernel* of an ovule, 297, or seed, 322.
- Key-fruit*, 314.
- Kidney-shaped*: see *Reniform*; 157, fig. 245.
- Kingdom*, 362, 15.
- Kinic acid*, 433.
- Kino*, 414.
- Knot*: see *Node*, 92.
- Knotted*: a cylindrical body swollen into knobs at intervals.
- Krameriaceæ*, 412.
- Labellum*: the lip, or lower petal of an Orchideous flower.
- Labiataæ*, 450.
- Labiate*: two-lipped, 278.
- Labiatifloræ*, 436.
- Lac*, 475.
- Laciniate*: slashed; cut into narrow incisions; these are called *laciniae*.
- Lactescent*: yielding milky juice.
- Lacunose*: full of depressions or excavations (*lacunæ*).
- Lacustrine*: belonging to lakes.
- Ladanum*, 394.
- Lavigate*: smooth as if polished.
- Lageniform*: shaped like a Florence flask (*lagena*).
- Lalo*, 399.
- Lamellæ*: thin plates, like the gills of an Agaric, 507, &c.
- Lamellar*, or *lammellate*: composed of flat plates.
- Lamina* (a plate): the blade of a leaf, petal, &c., 145, 276.
- Lanate*, *lanose*: woolly; i. e. clothed with soft interlaced hairs.
- Lanceolate*: lance-shaped; fig. 239.
- Lanuginous*: cottony or woolly.
- Latent buds*, 167.
- Lateral*: belonging, or attached to, the sides of an organ.
- Latez*: milky or proper juice, 49.
- Laticiferous tissue* or *vessels*, 49.
- Lauraceæ*, or *Laurineæ*, 466.
- Lax*: loose; the opposite of close or crowded.
- Layering*, 102.
- Leaf*, 133.
- Leaf-arrangement* (*phyllotaxis*), 133.
- Leaf-bud*, 72, 93.
- Leaf-green*, 58.
- Leaflet*: a separate piece or partial blade of a compound leaf, 163.
- Leaf-stalk*, 145, 170.
- Leaf-scars*, 94.
- Leathery*: see *Foliaceous*.
- Légume*: a fruit like a *Pea-pod*, 315.
- Legumine*, 198.
- Leguminosæ* (*Leguminous Plants*), 412.
- Leguminous*: relating to legumes.
- Lemnaceæ*, 486.
- Lemon*, 401.
- Lentibulaceæ*, 445.
- Lenticels*: little spots on the bark, whence roots often issue.
- Lenticular*: lens-shaped; double-convex.
- Lentiginosæ*: freckled, or dusky-dotted.
- Lepals*: sterile transformed stamens.
- Lepidote*: leprous; scaly or scurfy, 52.
- Leucanthous*: white-flowered.
- Liber*: the inner fibrous bark, 120, 127.
- Lid*: see *Opcrculum*, 502.
- Lichenes* (*Lichens*), 505.
- Lichenology*: the part of Botany devoted to Lichens.
- Licorice*, 414.
- Ligneous*: woody in texture.
- Lignine*, 36, 195.
- Lignum-vitæ*, 405.
- Ligulate*: strap-shaped, 255; having a
- Ligule*: a strap-shaped corolla, 255, fig. 325, *d*; the appendage between the blade and the sheath of the leaf in Grasses, 170.
- Ligulifloræ*, 436.
- Liguliflorous*: when a head consists of ligulate flowers only, as *Cichory*, fig. 323.
- Liliaceæ*, 493.
- Liliaceous*: lily-like, 276.
- Limb* (*limbus*, a border); the expanded part or border of a corolla, calyx, &c., or the lamina or blade of a petal, &c., 145, 276.
- Limbate*: bordered.
- Lime*, 401.
- Limnanthaceæ*, 404.
- Linaceæ*, 402.
- Line*: the twelfth of an inch. (In decimal measures, the tenth of an inch.)
- Linear*: narrow and much longer than broad, the two margins parallel; fig. 240.
- Lineate*: marked with lines.
- Lineolate*: marked with fine or obscure lines.

- Linguiform*, or *lingulate*: tongue-shaped, as the leaves of Hound's-tongue.
- Lip*: the two lobes a bilabiate calyx or corolla; the lower petal of an Orchideous plant.
- Littoral*, or *litoral*: growing on shores.
- Livid*: pale lead-color.
- Loasaceæ*, 421.
- Lobe*: any division or projecting part of an organ, especially a rounded one, 275.
- Lobed, lobate*: divided into lobes; fig. 260, 264.
- Lobeliaceæ*, 438.
- Lobulate*: bearing small lobes (*lobuli*).
- Locellate*: having secondary cells (or *locelli*).
- Locellus* (plural, *locelli*): a secondary cell, or a division of a cell.
- Loculament*, 316; same as *loculus*.
- Locular*: having cells.
- Loculicidal*, or *loculicidal*: dehiscence opening directly into the back of a cell; 316, fig. 583, 585.
- Loculose*: partitioned off into cells, as the pith of Poke, &c.
- Loculus* (plural, *loculi*): the cells of an ovary, anther, &c.
- Locusta*: a spikulet or flower-cluster of Grasses.
- Lodicules* (*lodicule*): the minute scales inside of the paleæ of Grasses, 497.
- Loganiaceæ*, 433.
- Lotus*, 414.
- Loment*: a jointed legume; 315, fig. 581.
- Lomentaceous*: bearing or resembling a loment.
- Longitudinal tissue or system*, 45, 50, 112.
- Lonicereæ*, 431.
- Loranthaceæ*, 469.
- Lorate*: thong-shaped.
- Lucid*: shining.
- Lunate*: crescent or half-moon shaped.
- Lobulate*: diminutive of the last.
- Lupuline*: waxy grains on the scales of Hops.
- Lurid*: dingy brown.
- Lutescent*: yellowish. (*Luteus*: yellow).
- Lycopodiaceæ*, 501.
- Lycotropous*, or *lycotropal*: an orthotropous ovule curved into a horse-shoe form.
- Lyrate, lyre-shaped*, 161, fig. 138, 278.
- Lyrate pinnate*, 164, fig. 285.
- Lythraceæ*, or *Lytharieæ*, 418.
- Mace*: the arillus of Nutmeg, 322, 383.
- Maculate*: spotted or blotched.
- Madder*, 432.
- Magnoliaceæ*, 381.
- Mahogany*, 401.
- Maize*, 498.
- Male flower*, 261.
- Malpighiaceæ*, 409.
- Malpighiaceous hairs*: hairs fixed by their middle, as in the foregoing order, in Cornus, &c.
- Malvaceæ*, 397.
- Mammillate*, or *mdmillar*: bearing little prominences on the surface.
- Mammiform*: tent-shaped.
- Mammee-apple*, 400.
- Mammose*: bearing larger prominences, like breasts.
- Mango*, 406.
- Mangosteen*, 400.
- Manicate* (gloved): covered with a woolly coat which may be stripped off whole.
- Manilla hemp*, 490.
- Manna*, 460.
- Many-cleft*: cut as far as the middle into several divisions, 159.
- Many-headed*: see *Multipital*.
- Marantaceæ*: see *Cannaceæ*.
- Marcescent*: gradually withering without falling off, 279.
- Marchantiaceæ*, 504.
- Marginal*: belonging to the margin.
- Marginate*: furnished with a margin of different texture or color from the rest.
- Maritime*: belonging to the sea-shore.
- Markings on cells*, 3, 6.
- Marmorate*: marbled.
- Marsiliaceæ*, 502.
- Mas*: male, masculine; belonging to the stamens.
- Masked*: see *Personate*, 278.
- Mealy*: see *Farinaceæ*.
- Medial*: belonging to the middle.
- Medulla*: pith, 118.
- Medullary rays*, 117, 119.
- Medullary sheath*, 119.
- Medullose*, or *medullary*: pith-like.
- Meiostemonous*: having fewer stamens than petals.
- Melanospermææ*, 509.
- Melanthaceæ*, 494.
- Melastomaceæ*, 418.
- Meliaceæ*, 401.
- Melon*, 423.
- Membranaceous*, or *membranous*: thin and soft, like a membrane.
- Meniscoid*: shaped like a meniscus or concavo-convex lens.
- Menispermaceæ*, 383.
- Menyanthideæ*, 457.
- Merénchyma*, 41.
- Méricarp*: half a cremocarp, 426.
- Merismatic*: dividing into parts, 28.
- Merithall*: a name for an internode.
- Mercous*, in Greek compounds: the parts

- of a flower: see *Dimerous*, *Trimerous*, &c.
- Mesembryanthemaceæ*, 397.
- Mesocarp*: the middle layer of a pericarp, 310.
- Mesophileum*: the middle bark or green layer, 121.
- Mesophyllum*: the parenchyma of a leaf between the skin of the two surfaces.
- Metamorphosed*: that which has undergone.
- Metamorphosis*: the transformation of one organ into another homologous one, 228, 231.
- Micropyle*: the orifice of a seed, 298.
- Midrib*: the central or main rib, 155.
- Milky juice*, 49.
- Mimoseæ*, 413.
- Mineral constituents* of plants, 179.
- Miniate*: vermilion-color.
- Mitriform*: mitre-shaped, 503.
- Mollugineæ*, 395.
- Monadelphia*, 513.
- Monadelphous*: with filaments united into a tube, or ring; 280, fig. 462.
- Monandria*, 512.
- Monandrous*: with a single stamen, 279.
- Monanthous*: one-flowered.
- Montiform*: necklace-shaped; cylindrical and contracted at intervals.
- Monimiaceæ*, 382.
- Monkey-bread*, 399.
- Mono-*, in Greek compounds: one or single.
- Monocarpellary*: of one carpel.
- Monocarpic*, or *monocarpian*: once-fruiting, 101.
- Monocephalous*: bearing a single head.
- Monochlamydeous*: with a single floral envelope; i. e. apetalous, 260.
- Monoclinous*: hermaphrodite.
- Monocotyledonous*: one-cotyledoned, 79, 326.
- Monocotyledons* or *Monocotyledonous Plants*, 113, 326, 370, 482.
- Monœcia*, 513.
- Monœcious*: stamens and pistils in separate flowers on the same individual, 262.
- Monogamia*, 516.
- Monogýnia*, 515.
- Monogynous*: with one pistil or style, 287.
- Monocious*: same as monœcious.
- Monómerous*: the parts of the flower single, 234.
- Monopetalous*: one-petalled, but it is used for gamopetalous, viz. petals more or less united into one body, 249, 275.
- Monophyllous*: one-leaved, of one piece, 275.
- Monopterous*: one-winged.
- Monosperous*: one-stoned.
- Monospalous*: the calyx of one piece, 249.
- Monospermous*: one-seeded.
- Monostichous*: in one vertical rank, 134.
- Monostylous*: with one style.
- Monotropææ*, or *Monotropaceæ*, 440.
- Monster*, monstrous (430): developed in an unnatural manner.
- Morphine*, 57.
- Morphology*, 14, 60, 224.
- Morphous*: the manner of development.
- Moschate*: exhaling the odor of musk.
- Moulds*, 65.
- Mucilage*: dissolved vegetable jelly, or dextrine, 55, 193.
- Mucilaginous*, *mucosæ*, or *muscosæ*: slimy.
- Mucro*: a short, sharp point.
- Micronate*: abruptly tipped with a mucro; 162, fig. 276, 231.
- Mucronulate*: tipped with a minute mucro.
- Mulberry*, 475.
- Mule*: a hybrid.
- Multangular*: many-angled.
- Multi-*, in Latin derivatives: many; as, *Multicapital* (*multiceps*): many-headed; where several buds or shoots proceed from the crown of one root.
- Multifarious*: many-sided.
- Multifid*: many-cleft, 159.
- Multiflorous*: many-flowered.
- Multijugate*: in many pair.
- Multilocular*: many-celled.
- Multiple*: compound.
- Multiple fruits*, 309, 318.
- Multiserial*: in several horizontal ranks.
- Multiseptate*: many-partitioned.
- Muricate*: rough with short and hard points.
- Muriculate*: minutely muricate.
- Musaceæ*, 490.
- Muscardine*, 508.
- Muscariform*: brush-shaped.
- Musci* (Mosses), 502.
- Musciform*: moss-like.
- Muscology*: the department of Botany which treats of Mosses.
- Mustard*, 389.
- Muticous*: pointless; blunt.
- Mycelium*, 507.
- Mycology*, or *Mycetology*: the department of Botany which treats of Fungi.
- Micropyle*: see *Micropyla*.
- Myricaceæ*, 477.
- Myrsinaceæ*, 443.
- Myristicaceæ*, 383.
- Myrrh*, 407.
- Myrtaceæ*, 418.

- Naiadaceæ*, 487.
Naked flowers: same as *achlamydeous*; or destitute of involucre, &c.
Naked ovules and seeds, 296, 320.
Names of species and genera, 363; of orders, tribes, &c., 373.
Nápisiform: turnip-shaped, 84.
Natant: floating under water.
Natural system, 365, 366.
Naturalized: species introduced, but growing completely spontaneous, and propagating by seed.
Navicular: boat-shaped.
Nebulose: clouded.
Neck: the junction of root and stem.
Necklace-shaped: see *Moniliform*.
Nectar: the honey of a flower, or any sweetish exudation.
Nectary (nectarium): a place or thing in which nectar is secreted: formerly applied also to any anomalous part or appendage of a flower, whether known to secrete honey or not, as to the spur-shaped petals of *Aquilegia*, fig. 647, or the two singular-shaped petals of *Aconitum*, 257, fig. 402, 404.
Needle-shaped: see *Acerose*.
Nelumbiaceæ (Nelumbo), 385.
Némeous: filamentose; composed of threads.
Nervation: the arrangement of the nerves: parallel and simple veins.
Nerved: nervate; furnished with nerves, 154.
Nervose: abounding in nerves.
Netted: same as *reticulated*.
Netted-veined, 154.
Neurose: same as *nervose*.
Neutral: without sexes.
Neutral flowers: having neither stamen nor pistil, 263, 436.
Neutral quaternary products, 196.
New Zealand Hemp, 492.
Nidulant: nestling in.
Nitid (nitidus): smooth and shining.
Niveous: snow-white.
Nodding: curved so that the apex hangs down.
Node (knot): the place on a stem where a leaf is attached, 92.
Nodose: knotty; swollen in some parts, contracted at others.
Nódulose: diminutive of the last.
Normal: according to rule.
Notate: marked by spots or lines.
Notorhizal: the radicle bent round to the back of one cotyledon; same as *incumbent*.
Nucumentaceous: nut-like.
Nucelle: same as *nucleus*.
Núciiform: nut-like.
Nucleus: the kernel, 297, 320, 322.
Nucleus of a cell, 26.
Nuculanium: a name for a berry like a grape.
Núcule: a diminutive nut, stone, or kernel.
Núculose: containing *nucules* or *nutlets*.
Numerous: same as *indefinite*.
Nut, 314.
Nutlet: a small nut, or the small stone of a berry-like drupe.
Nutmeg, 383.
Nutant: nodding.
Nutrition, 61, 177.
Nux-vomica, 434.
Nyctaginaceæ, 463.
Nymphæaceæ, 385.
Oat, 498.
Ob- (over against) signifies inversely; as,
Obcompressed: flattened fore and aft, instead of laterally.
Obcordate: heart-shaped inverted; 162, fig. 274, 233.
Obláncolate: lance-shaped, but broader upwards.
Oblique, referring to shape, unequal-sided, 165.
Obliteration, 309.
Oblong: elliptical, or approaching it, and much longer than wide; fig. 242.
Obóvate: inversely ovate; 157, fig. 232.
Obtuse: blunt; the apex an obtuse angle; 162, fig. 270, 236.
Obverse: same as *ob*.
Obvolute: a modification of *convolute*, 145.
Ocellate: eyed; a circular patch of color within another patch.
Óchrea (a boot): a tubular stipule; 171, fig. 305.
Óchreate: furnished with *ochreæ*.
Ochroleicous: ochre-colored (pale dull yellow) verging to white.
Octo-: eight; in composition in such words as the following.
Octagynia, 515.
Octógynous: with eight pistils or styles.
Octámerous: the parts in eights.
Octandria, 512.
Octándrous: with eight stamens.
Octopétalous: of eight petals, 276.
O'culate: eyed; same as *ocellate*.
Officinal (belonging to the shop): applied to plants, &c. used in medicine or the arts.
Offset, 102.
Oilnut, 469.
Oils, 56, 57.

- Okra, 398.
 Oleaceæ, 459.
Oleraceous: of the nature of, or fit for, pot-herbs.
Oliyo, in Greek derivatives: few; as
Oligandrous: having few stamens.
Oligospermous: few-seeded.
 Olive, Olive-oil, 460.
 Onagraceæ, 419.
 One-celled plants, 61.
One-sided: see *Secund* and *Unilateral*.
Opiphordia: the larger and compound spores of *Lycopodiaceæ*.
Opaque: the reverse of shining; dull.
Operculate: furnished with a lid or
Operculum: a lid, such as that of the spore-case of Mosses, 502.
 Ophioglossæ, 501.
 Opium, 389.
Opposite (leaves, &c.): opposed to alternate, that is, placed over against each other, 78, 97, 133, 141. A stamen, &c. is said to be opposite a petal, when it stands before it (248), as in fig. 435 and 670.
Oppositifolious: opposite a leaf, as the tendrils of *Vitis*, fig. 767, and the peduncles of *Phytolacca*, fig. 1086.
 Orange, 401.
Orbicular: circular in outline.
 Orchidaceæ, 488.
 Orders, 359.
Ordinal: relating to orders.
Organic constituents, 179, 180.
 Organization, 17.
Organography, 14, 60.
Organogeny: the development or formation of organs, 268.
 Organs, 18.
Organs of Reproduction, 70.
Organs of Vegetation, 68, 70, 204.
 Orobanchaceæ, 446.
 Orris-root, 491.
Orthoploceous (embryo): with incumbent and conduplicate cotyledons, as in *Mustard*.
Orthotropous, or *orthotropal* ovule; 298, fig. 526. The term when applied to the embryo is used as the contrary of *antitropous*, i. e. having the radicle next the hilum, as in an *anatropous* seed.
 Osage Orange, 475.
 Osmundaceæ, or *Osmundinæ*, 501.
Ossæous: of the texture of bone.
 Ouari Poison, 434.
Oval: broadly elliptical; 157, fig. 229.
Ovary: the ovule-bearing portion of a pistil, 223, 287.
Ôvate: egg-shaped, or like the longitudinal section of an egg, fig. 241.
Ovoid: a solid ovate or oval.
- Ôvulate*, *ovuled*, or *ovuliferous*: bearing ovules.
Ôvule: an unimpregnated seed or body destined to become a seed, 223, 297.
 Oxalidaceæ, 404.
Palate: an inward projection of the lower lip of a personate corolla; 278, fig. 459, 460.
Palea, or *palet*: a chaff; one of the bracts on the receptacle of *Compositæ*, 215, 435; one of the inner bracts or glumes of *Grasses*, 497.
Paleaceous: chaff-like, or bearing chaff.
Palæola: diminutive of *palea*; one of the minute innermost scales of the flower of *Grasses*. See *Squamella*.
 Palmæ (Palms), 484.
Palmate: lobed or divided so that the sinuses all point to the apex of the petiole, either moderately, as in a Maple-leaf, or so as to make the leaf compound, as in *Horsechestnut*, when it is the same as *Digitate*; 161, 163, 164.
Palmately lobed, *cleft*, *parted*, &c., 161.
Palmately 2 - plurifoliate, 164.
Palmately veined, 156.
Palmatifid: palmately cleft; fig. 263.
Palmatisect: palmately divided; fig. 267.
Paludose, *palustrine*: inhabiting marshes.
 Pandanaceæ, 485.
Pandurate, or *panduriform*: same as fiddle-shaped.
Panicle: a raceme, branched irregularly; 216, fig. 326.
Panicled, or *punciculate*: arranged in a panicle.
 Papaveraceæ, 388.
 Papaw, 383, 422.
 Papayaceæ, 422.
Papery: of the consistence of letter-paper.
 Papilionaceæ, 413.
Papilionaceous: butterfly-like, 253.
Papillose, or *papillate*: bearing small, soft projections (papillæ, nipples or pimples).
Pappose, or *pappiferous*: bearing a *Pappus* (thistle-down), 260, 314, 435.
Papyraceous: papery.
 Papyrus, 496.
Paracorolla: an appendage or duplicate of a corolla, such as was once called a nectary.
Parallel-veined or *nerved*, 154.
Pardaphysis: jointed thread-like bodies accompanying the pistillidia of Mosses.

- Parasitic plants, or Parasites*: living on the juices of other plants, 88.
Parastemon: same as *Staminodium*.
Parénchyma: soft cellular tissue, 41.
Parietal: attached or belonging to the walls, 292.
Partes: walls of an ovary, &c.
Paripinnate: same as abruptly pinnate, 163.
Parnassiaceæ, 394.
Parsnip, 426.
Parted, or partite: cut almost through; 160, fig. 262, 266.
Partial peduncle, 211.
Partial petiole, 164.
Partial umbel, 216.
Parthenogenesis, 300, 340.
Passifloraceæ (Passion-flowers), 422.
Patelliform: kneepan-shaped.
Patent: spreading wide open.
Patulous: moderately spreading.
Pauci-, in Latin derivatives: few; as *Pauciflorous*: few-flowered.
Peach, 415.
Pear, 416.
Pear-shaped: ovoid at the extremity, conical at the base.
Pectinate: pinnatifid with close-set and equal lobes, like the teeth of a comb (*pecten*), 160.
Pectine, and Pectic acid, 55, 310.
Pedate: palmate, with the lateral lobes again lobed; appearing like a bird's foot, 161, fig. 249.
Pedately: in a pedate mode.
Pedicel: the stalk of a particular flower, 211.
Pedicellate, pedicelled: having a pedicel.
Peduncle: a flower-stalk in general, either of one blossom or a whole cluster, 211.
Pedunculate, peduncled: having a peduncle.
Peloria, 278.
Peltate: shield-form or target-shaped; fixed by the centre or some part of the lower surface; fig. 248, 681.
Peltinerved: peltately veined.
Pelciform: open cup-shaped.
Pendient, pendulous: hanging down.
Pentacillate, pentacilliform: tipped with a brush of hairs, like a camel's-hair pencil.
Pennate: same as pinnate.
Penniform: feather-like.
Penninerved: same as pinnately nerved or veined.
Penta-, in Greek derivatives: five; as *Pentacarpellary*: of five carpels.
Pentacoccus: of five cocci.
Pentagynia, 515.
Pentogynous: with five pistils or styles, 287.
Pentamerous: of five parts; 234, 239, fig. 354.
Pentandria, 512.
Pentandrous: having five stamens, 279.
Pentapetalous: of five petals, 276.
Pentaphyllous: five-leaved, 275.
Pentapterous: five-winged.
Pentasepalous: of five sepals, 274.
Pentastichous: in five vertical ranks, 135.
Pepo: a Gourd-fruit, 312.
Pepper, 456, 469.
Perennial: lasting year after year, 84.
Perfect flower: one having both stamens and pistils, 261.
Perfoliate: when the stem appears to pass through the leaf; 165, fig. 293, 294.
Perforate: pierced with holes, or having transparent dots which look like holes.
Pergameneous, or pergamenteous: like parchment.
Peri-, in Greek derivatives: around.
Périanth (perianthium): the floral envelopes collectively, either of one set (calyx) or of two sets (calyx and corolla), 222.
Péricarp: the ovary in fruit, 308.
Pericarpic: belonging to the pericarp.
Perichætal: relating to the
Périchæth, or perichæctium: the cluster of peculiar leaves surrounding the base of the fruit-stalk of Mosses.
Periclinium: a name for the involucre of *Compositæ*.
Périderm: same as *Epiphloeum*.
Périgone, or perigonium: same as *Perianth*.
Perigynium: bristles or other organs, of doubtful nature, around the pistil in *Cyperaceæ*, 497.
Perigynous: borne on the calyx; literally around the ovary; i. e. when the petals or stamens are adnate to the base of the ovary or to the calyx; 251, 268, fig. 388, 389, 281.
Peripetalous: around the petals.
Peripherie: surrounding the circumference, 325; as the embryo around the albumen in fig. 621.
Périsperm: the albumen of the seed, 322, or that albumen which is formed in the tissue of the nucleus, 323.
Péristome, 502.
Peritropous, peritropal (seed): horizontal to the axis of the fruit.
Perpendicular system of the stem, 112.
Persimmon, 443.

- Persistent* : remaining, as the leaves of evergreens through the winter, 172; and the calyx, &c. of many plants until the fruit is formed, 279.
- Personate* : masked; 278, fig. 459, 460.
- Pertuse* : having slits or holes.
- Pérulate* : having *pérulæ* or bud-scales.
- Peruvian Bark, 432.
- Petal* : a leaf of the corolla, 222.
- Pétaline*, or *petuloid* : petal-like, in color and texture, 260.
- Pétiolar* : borne on the petiole.
- Pétiolate*, *petioled* : having a petiole.
- Pétiole* : leafstalk, 145, 170.
- Petioclulate* : the leaflet stalked, 164.
- Petiolule* : the stalk of a leaflet, 164.
- Phænogamous*, or *phanerogamous* : having manifest flowers, 69.
- Phænogamous* or *Phanerogamous* Plants, 69, 369, 375.
- Phalanges* : bundles of adelphous or clustered stamens.
- Phoranthium* : the receptacle of Compositæ.
- Phrymaceæ, 450.
- Phycology* : same as Algology.
- Phylla* : leaves, 274. *-phyllous* : leaved, as 3-*phyllous*, three-leaved, &c.
- Phyllodineous* : bearing or resembling a *Phyllodium* : a dilated petiole taking the place of a blade, 170.
- Phyllotaxis*, or *phyllotaxy*, 133.
- Physiological Botany, 14, 17.
- Phytelphantæ, 485.
- Phytography* : descriptive Botany.
- Phytolaccaceæ, 463.
- Phytology* : Botany in general.
- Phyten* : a simple plant-individual, or plant-element, 96.
- Phytotomy* : vegetable anatomy, 14.
- Pileate*, *pileiform* : like a cap or *Pileus*, 507.
- Pileorhiza* : the cap of a root, as found in some aquatic plants; fig. 102.
- Piliferous* : bearing or tipped with hairs (*pili*).
- Pilose* : hairy, as distinguished from woolly or downy; i. e. distinct and straight, but not rigid hairs.
- Pilosity* : hairiness.
- Pimento, 418.
- Pine-apple, 492.
- Piney Tallow, 400.
- Pink-root, 435.
- Pinnæ* : one of the primary divisions of a pinnately compound leaf, 164.
- Pinnate*, *pinnated* : a compound leaf with leaflets arranged along the sides of a common petiole; 163, fig. 288-290.
- Pinnately cleft*, *lobed*, *parted*, &c., 160.
- Pinnately 3-plurifoliate*, &c., 164.
- Pinnately veined*, 155, 160.
- Pinnatifid* : pinnately cleft; fig. 261.
- Pinnatisect* : pinnately divided; fig. 263.
- Pinnule* : a secondary division of a pinnately compound leaf.
- Piperaceæ, 469.
- Piperine, 469.
- Pisiform* : pea-shaped.
- Pistachio-nut, 406.
- Pistil* : the ovule-bearing organ of a flower, 223, 287.
- Pistillate* : furnished with pistils, or pistils only, 261.
- Pistillidium*, 337.
- Pitch, 480.
- Pitchers* : see *Ascidium*; 169, 387, fig. 299-301.
- Pitcher-shaped* : campanulate or tubular, but with a narrower mouth.
- Pith*, 118.
- Pits*, 37.
- Pitted* : marked with small depressions.
- Pitted tissue*, 45.
- Placenta* : the place or part of the ovary which bears the ovules or seeds, 289.
- Placentation* : the arrangement of placenta.
- Placentiferous* : bearing the placenta.
- Placentiform* : nearly the same as quoit-shaped.
- Plaited* : see *Plicate*, 273.
- Plane* : flat.
- Plantaginaceæ, 444.
- Platanaceæ, 476.
- Platyedreous* : broad-fruited.
- Pleio*, in Greek derivatives : full of, or many; as
- Pleiospermous* : many-seeded, &c.
- Pleurénchyma* : woody tissue, 41.
- Pleurorhizal* : embryo with the radicle lying against the side or edge of the cotyledons; same as *acumbent*.
- Plicate*, *placcative* : thrown into longitudinal plaits (*placcæ*); folded, 144, 273.
- Plum, 415.
- Plumbaginaceæ, 444.
- Plumose* : feathered; when bristles, &c. have fine hairs on each side like the plume of a feather, as the pappus of Thistles, &c.; fig. 890.
- Plumule* : the bud or growing point of the embryo above the cotyledons, 71, 324.
- Pluri*, in words of Latin origin : several, at least more than one; as
- Pluriflorous* : several-flowered.
- Plurifoliate* : bearing several leaflets.

- Plurilacunar*: several-celled.
Poculiform: deep cup-shaped.
Pod: a dry dehiscent fruit, 315.
Podosperma: seed-stalk, 297.
Podostemaceæ, 471.
Pointless: see *Muticous*.
Pointletted: same as *Apiculate*.
Polemoniaceæ, 453.
Pollen: the contents of the anther, 223, 285.
Pollen-tube, 286, 302.
Pollinia: pollen-masses, 286, 489.
Polliniferous: bearing pollen.
Poly-, in Greek compounds: numerous.
Polyadelphis, 513.
Polyadelphous: having the filaments in several sets, 280.
Polyandria, 512.
Polyandrous: with numerous stamens, especially when inserted on the receptacle, 242, 280.
Polyanthous: many-flowered.
Polydripic: fruiting many times, i. e. year after year; perennial, 101.
Polycephalous: bearing many heads.
Polycladus: much-branched.
Polycoccus: of several cocci.
Polycotyledonous: having several cotyledons, 79, 326.
Polygalaceæ, 411.
Polygamia, 513, 515.
Polygamous: having both perfect and separated flowers, 262.
Polygonaceæ, 465.
Polygonous: many-angled.
Polygyna, 515.
Polygynous: with numerous pistils or styles, 287.
Polymerous: formed of many members.
Polyomorphic: various in form.
Polypetalous: having distinct petals, 249, 275.
Polyphore: a common receptacle of many carpels, as in Strawberry.
Polyphyllois: many-leaved or several-leaved, 275.
Polypodiaceæ, or *Polypodineæ*, 501.
Polyrhizal: many-rooted.
Polysepalous: of two or more distinct sepals, 249, 275.
Poly spermous: many-seeded.
Polysporous: containing many spores.
Polystemonous: with many stamens.
Pome: an apple, pear, &c., 312.
Pomeæ, or *Pomaceæ*, 416.
Pomegranate, 418.
Pomiferous: pome-bearing.
Pomology: the department of Botany relating to fruits.
Pontederiaceæ, 495.
Porose: porous, having holes.
Portulacaceæ, 396.
Posterior (in the flower): next the common axis, 237.
Posticous: same as *extrorse*.
Potato, 456, 455.
Pouch: see *Silicle*, 317.
Præfloration: same as *Æstivation*, 269.
Præfoliation: same as *Vernation*, 143.
Præmorse: as if bitten off.
Prickly: armed with
Prickles, 52.
Prinine: outer coat of the ovule, 298.
Primordial leaves, 143; *uricle*, 26.
Primulaceæ, 443.
Prismatic, prismatical: with flat longitudinal faces, separated by angles.
Process: any projection from a surface.
Procumbent: lying along the ground, 102.
Produced: prolonged or extended.
Pro-embryo, 338.
Proliferous (bearing offspring): developing new branches, flowers, &c. from the older ones, or from unusual places.
Prone: lying face downwards.
Proper juices, 57.
Prosenchyma, 41.
Prosenthesis, 236.
Prostrate: lying flat on the ground, 102.
Proteaceæ, 468.
Proteine, 27, 53, 57, 196.
Proteranthous: where flowers are produced earlier than the leaves.
Prothallus, or protothallus, 338.
Protophytes: *Algae* and *Lichenes* are so called.
Protoplasm, 26, 53, 57, 196.
Pruinatè, pruinose: as if frosted over.
Pruiniform: plum-shaped.
Pseudo-bulb: a kind of corm, as of epiphytic *Orchidaceæ*.
Pseudo-parasitic: same as *epiphytic*.
Pterocarpous: wing-fruited.
Pteroid: wing-like.
Pubescent: clothed with soft or downy hairs, or *pubescence*.
Pugioniform: dagger-shaped.
Pulque, 491.
Pulse, 413.
Pulveraceous, or pulverulent: dusty or powdery on the surface.
Pulvinate: cushioned.
Pulvinus (a cushion): an enlargement at or below the base of a leafstalk.
Pumpkin, 423.
Punctate: dotted as if by punctures.
Pungent: pricking; rigid-pointed.
Pustulate: blistered.
Putamen: the stone or shell of a drupe, 310, 312.
Pyrene: the stones of small drupes; same as *nucules*.

- Pyriform*: pear-shaped.
Pyroleæ, or *Pyrolaceæ*, 440.
Pyridate: furnished with a lid, like a
Pyxidium, or *pyxis*: a pod opening by a
 lid; 317, fig. 575, 588, 950, &c.
- Quadrangular*: four-angled.
Quadri-, in Latin compounds: four.
Quadrifarious: in four vertical ranks.
Quadrifid: four-cleft.
Quadrifoliate: four-leaved.
Quadrifoliolate: of four leaflets.
Quadrifugate: four-paired.
Quadrupartite: four-parted.
Quandang-nuts, 460.
Quassia, 405.
Quaternary: consisting of four, 239.
Quaternary products, 53, 57, 196.
Quaternate: in fours.
Quercitron, *Quercine*, 476.
Quin-, in Latin compounds: five in
 number.
Quinary: consisting of five, 234, 239.
Quinate: in fives.
Quince, 416.
Quincinial: five-ranked; in a quincunx,
 135, 270.
Quinine, *Quinia*, 57, 433.
Quinquifarious: five-ranked.
Quinquifoliate: five-leaved.
Quinquifoliolate: of five leaflets.
Quinquelocular: five-celled.
Quinquina Bark, 433.
Quintuple: dividing into five parts.
Quintuple-ribbed, or
Quintupli-nerve, 156.
- Race*: a variety perpetuable by seed,
 356.
Raceme: an indefinite inflorescence with
 single pedicelled flowers arranged
 along a prolonged axis; 211, fig.
 307.
Racemiferous: bearing racemes.
Racemiform: resembling a raceme.
Racemose: bearing or resembling ra-
 cemes.
Rachis: see *Rhachis*.
Radial: belonging to the border or ray.
Radiate, *radiant*: spreading from or
 arranged around a centre; having
 rays.
Radiated-veined, 156.
Radical: relating to the root (*radix*).
Radical leaves: those apparently spring-
 ing from the root, 143.
Radicant: rooting.
Radicle: a diminutive root or rootlet.
Radiciflorous: flowering from the root,
 or apparently so.
Radiciform: appearing like a root.
Radicle: a diminutive root; the part of
 an embryo below the cotyledons,
 71, 324.
Radii: rays.
Rafflesiaceæ, 463.
Ramal, or *ramcal*: relating to branches,
 143.
Ramenta, *raments*: thin chaffy scales in
 place of hairs.
Ramentaceous: bearing raments, as the
 stalks of many Ferns.
Ramification, 97.
Ramiflorous: flowering on the branches.
Ramose: bearing branches (*rami*);
 branchy.
Ramulose: bearing many branchlets
 (*ramuli*).
Ranunculaceæ, 380.
Raphe: see *Rhaphé*.
Raphides: crystals in plants, 59
Rare: thinly set; sparse or few.
Raspberry, 416.
Ray: the marginal flowers of a head,
 when different from the rest, 436;
 the branches of an umbel, &c.
Ray-flower, 436.
Receptacle of the flower, 224, 266.
Receptacle of inflorescence, 211, 215.
Recess: same as sinus.
Reclinate, *reclined*: falling or turned
 downwards.
Reclinerved: parallel-veined.
Rectiserial: in rectilinear ranks, 141.
Recurved: curved, especially curved
 backwards.
Reduplicate, *reduplicative*, 273.
Reflexed: bent downwards or back-
 wards.
Refracted: suddenly bent backwards.
Regular: the members alike in size and
 form, 239, 277.
Réniform: kidney-shaped; same as
 round-heart-shaped, but the breadth
 greater than the length; fig. 245.
Repidid: bowed, the margin obscurely
 sinuate, 159, fig. 257.
Repent: same as creeping, 102.
Replicate: folded back.
Replum (a door-case); the frame-like
 placentæ of *Papaveraceæ*, &c. from
 which the valves of the pod fall
 away in dehiscence.
Reproduction, 20, 21, 61;—in *Cryptoga-
 mous plants*, 330.
Reproductive organs, 70.
Reptant: same as repent.
Resedaceæ, 391.
Resins, 195.
Respiration, 178, 199, 202.
Restiaceæ, 496.
Resupinate: underside up, or having that
 appearance.
Reticulated: netted, 154.

- Reticulated ducts*, 46.
Retinaculum: a stay or holdfast: applied to the processes bearing the seeds of *Acanthaceae*, &c.
Retinerved: same as reticulated.
Retrocurved: same as recurved.
Retroflected: same as reflexed.
Retrofracted: same as refracted.
Retrorse: backwards; directed backwards.
Retroverted: turned upside down.
Retuse: slightly notched at a rounded apex; 162, fig. 272.
Revolute, revolute: rolled backwards, 144.
Rhachis (back-bone): the axis of a spike, &c., 211.
Rhamnaceae, 408.
Rhaphe of an ovule or seed, 299, fig. 529, r.
Rhatany, 412.
Rhizanthous: root-flowered; as when a flower (like *Rafflesia*, fig. 150), or a cluster of flowers, &c. without green foliage (like *Beech-drops*), is parasitic by what answers to roots, on some foster plant.
Rhizocarpous (root-fruited): having a perennial root.
Rhizoma: rootstock, 106.
Rhizomorphous: root-like.
Rhizophoraceae, 419.
Rhodospiraceae, 509.
Rhombic: rhomb-shaped.
Rhomboidal: approaching a rhomboid in form.
Rhubarb, 466.
Rib: a strong nerve or part of the framework of a leaf, &c., 145, 155.
Ribbed: when strong nerves or ribs run lengthwise through a leaf, &c.
Ricciaceae, 504.
Rice, 498.
Rimose: with chinks or clefts (*rimæ*).
Ring of Ferns, 501; of Mosses, 503.
Ringent: grinning; when a bilabiate corolla is open, 278.
Riparious: along water-courses.
Root, 79.
Root-hairs, 81.
Rootlet: a very small root, or ultimate branch of a root.
Rootstock: same as *rhizoma*, 106.
Rosaceae, 415.
Rosaceous: rose-like, 276.
Rostellate: diminutive of rostrate.
Rostellum: a little beak.
Rostrate: beaked, bearing a
Rostrum: a beak-like projection.
Rosular, or rosulate: shaped like a rosette.
Rotate: wheel-shaped; 278, fig. 454.
Rotation in cells: see *Cyclosis*, 31.
Rotund, rotundate: of rounded outline.
Rough: see *Scabrid* or *Scabrous*.
Rubescens, rubicund: reddish or rosy.
Rubiaceae, 431.
Rubiginose: rusty reddish.
Ruderal: growing in rubbish.
Rudimentary: imperfectly or incompletely developed.
Rufescent: approaching to
Rufous: brown-red.
Rugose: wrinkled (*ruga*, a wrinkle).
Ruminated (albumen): penetrated with holes or channels; 323, 383, fig. 658.
Runcinate: saw-toothed, the teeth turned backwards, 161, fig. 279.
Runner, 102.
Running, 102.
Rupestrine: growing naturally on rocks.
Ruptile: bursting irregularly.
Rusty: see *Ferrugineous*.
Rutaceae, 405.
Rye, 498.
Sabuline, or sabulose: growing in sand.
Saccate, sacciform: sac-shaped, 278.
Sac of the amnios, 304.
Saffron, 491, 437.
Sagittate: arrow-headed, or arrow-shaped; lanceolate with a lobe at the base on each side pointing backwards; fig. 252.
Sago, 481, 485.
Salap, 489.
Salicaceae, or Salicinise, 478.
Salicine, 478.
Saline, salsuginous: growing in salt places, or impregnated with salt.
Salver-shaped: tubular and the border spreading flat at right angles to the tube; 277, fig. 457.
Salvinieae, 502.
Samarra: a key or winged indchiscent fruit, 314, fig. 577, 578.
Samaroid: resembling a samara.
Sambucaceae, 431.
Sandal-wood, 414, 469.
Santalaceae, 468.
Sap, 53, 190.
Sapindaceae, 409.
Sap-green, 408.
Sapodilla Plum, 443.
Sapotaceae, 443.
Sop-wood, 35, 124, 126.
Sarcocarp: the fleshy part of a drupe, 310, 312.
Sarmentaceous: bearing or resembling
Sarments: runners or long and flexible branches.
Sarraceniaceae, 387.
Sarsaparilla, 493.

- Saururaceæ*, 469.
Saw-toothed: same as *Serrate*.
Saxatile: living in rocky places.
Saxifragaceæ, 424.
Scabrate, *scabrid*, or *scabrous*: rough to the touch.
Scaldriform: ladder-shaped, or barred.
Scalariform ducts, 46.
Scales: any thin scale-like appendages; usually degenerated leaves, 105.
Scalloped: same as *Crenate*.
Scaly: furnished with scales, 95, 191.
Scammony, 455.
Scandent: climbing.
Scape: a flower-stalk rising from the ground or near it, 220.
Scapiform, or *scapoid*: resembling a scape.
Scar: see *Leaf-scar* and *Hilum*.
Scariosæ, or *scarios*: thin, dry, and membranaceous.
Scattered: either sparse, or without apparent symmetry of arrangement.
Schizandree, 382.
Scion: a shoot, especially one used for grafting.
Sciuroïd: like a squirrel's tail.
Scleranthææ, 396.
Sclérogen: same as *Lignine*, 36.
Scobiform, or *scobicular*: like sawdust.
Scorpioid: coiled round like a scorpion, as the branches of the cyme of *Heliotrope*.
Scrobiculate: pitted.
Scrophulariaceæ, 448.
Scrotiform: pouch-shaped.
Scurf: minute or bran-like scales on the epidermis, 52.
Scutate, *scutiform*: shield-shaped.
Scutelliform: shaped like a platter (*scutella*).
Secretions, 51.
Sectile: divided into portions.
Secund: all turned to one side of an axis.
Secundine: the second coat of an ovule, 298.
Seed, 70, 320.
Seed-vessel, 308.
Segment: one of the divisions or lobes of a leaf or other organ; 159, 275.
Ségregate: kept separate.
Semi-, in Latin compounds: half.
Semi-adherent: the lower half adherent.
Semi-amplexicaul: half-clasping.
Semicordate: half heart-shaped (divided lengthwise).
Semi-double: half-double.
Semi-floccular: when the flowers of a head are ligulate.
Semilunar, or *semilunate*: like a crescent or half-moon.
Seminal: relating or belonging to the seed.
Seminiferous: seed-bearing.
Semiorbicular: half-round.
Semioval: half of an oval, and
Semiovalate: half of an ovate figure, divided longitudinally.
Semiasagittate: arrow-headed with one lobe wanting.
Semiseptate: a partition reaching partly across.
Semiterete: half-cylindrical.
Sempervirent: evergreen.
Senna, 414.
Sensitive plants, 345.
Sepal: a calyx-leaf, 222.
Sépaline, *sepalous*: relating to sepals.
Sepaloid: resembling a sepal.
Separated flowers: the stamens and the pistils occupying separate blossoms, 261.
Septate: with a partition (*septum*).
Septicidal, or *septicide*: dehiscent through the partitions, i. e. by the lines of junction; 316, fig. 582, 584.
Septiferous: bearing a partition.
Septifragal: where the valves separate from the dissepiments, 317.
Septum (plural *septa*): a partition of any kind, 316.
Séréal, or *sériate*: arranged in rows.
Sericeous: silky.
Series: rank.
Serotinous: flowering or fruiting late.
Serrate: beset with teeth pointing forwards, like those of a saw, 159, fig. 254.
Serratures: the teeth of a serrate body.
Serrulate: serrate with fine teeth.
Sesameæ, 447.
Sésile (sitting): not stalked, 145, 211, 281.
Seta: a bristle, or bristle-like body, 52.
Setaceous, *setiform*: like a bristle.
Setigerous: bristle-bearing.
Setose: bearing or abounding with bristles.
Setula: diminutive of *Seta*.
Setulose: bearing minute bristles.
Sex: six; as in
Sexangular: six-angled.
Serfurious: six-rowed.
Sxpartite: six-parted, &c.
Shaggy: see *Villous*.
Sheath: a tubular body, enclosing or surrounding some other; as the base of the leaves of *Grasses*; 170, fig. 237.
Sheathing: forming a sheath; see *Vaginate*.
Shields: see *Apothecia*, 506.

- Shield-shaped*: see *Peltate*, 158, fig. 248, 681.
- Shoot*: any fresh branch.
- Shrub, shrubby*, 101.
- Sigillate*: as if marked with the impression of a seal, as in Solomon's Seal, fig. 168.
- Sigmoid*: curved like the Greek *sigma*, or letter S.
- Signs used in Botany, 517.
- Sileneæ*, 395.
- Silicle*: a pouch, or short pod of *Cruciferae*, 317, fig. 703.
- Siliculosa*, 515.
- Siliculate*: having or resembling a silicle.
- Siliqua*: a long pod of *Cruciferae*; 317, fig. 589.
- Siliquosa*, 516.
- Siliquose*: like a silique.
- Silk-cotton*, 399.
- Silky*: clothed with fine, appressed, and glossy hairs, producing a satiny surface.
- Silver-berry*, 468.
- Silver-grain*, 120.
- Simarubaceæ*, 405.
- Simple*: of one piece or rank.
- Simple fruits*, 309, 311; *leaves*, 162; *pistil*, 288.
- Sinistrorse*: turned to the left.
- Sinuate*: strongly wavy on the margin, with alternate convexities and concavities; 159, fig. 258.
- Sinus*: a re-entering angle or recess.
- Slashed*: same as *Laciniate*.
- Sleep of plants*, 344.
- Smilacææ*, 492.
- Smooth*: not pubescent or hairy, or else (and more strictly) not rough.
- Snake-root*, 412, 462.
- Soap-berry*, 410.
- Soboliferous*: bearing shoots (*soboles*).
- Social* (plants): growing gregariously.
- Solanacææ*, 456.
- Solitary*: single; alone.
- Soluble*: separating into parts.
- Sorediate*: bearing little patches on the surface.
- Sorose*: heaped, or bearing.
- Sorosis*: a fleshy multiple fruit, like a mulberry.
- Sori* (sing. *sorus*): heaps or patches, as those of the spore-cases of most Ferns, called in English *fruit-dots*, 501.
- Spathaceous*: bearing a
- Spathe*: the enveloping bract of a spadix, 213.
- Spathulate, or spatulate*: shaped like a druggist's spatula.
- Special directions, 341.
- Species*, 19, 354.
- Specific*: relating to species.
- Spermaphore*: a name for the placenta, or the funiculus of the seed.
- Spermatozoids*, 334.
- Spermic, or spermous*: relating to the seed.
- Spermoderm*: the outer seed-coat, 320.
- Spicate*: relating to or disposed in a spike.
- Spiciform*: spike-like.
- Spicula*: a spikelet.
- Spike*: a prolonged indefinite inflorescence with sessile flowers, 212.
- Spikelet*: a diminutive or secondary spike; the ultimate flower-clusters of Grasses.
- Spikenard*, 435.
- Spindle-shaped*, 84, fig. 138.
- Spine*, 104, 167.
- Spinescent*: tipped with a spine, 104.
- Spinose*: spiny, 104.
- Spinulose*: bearing diminutive spines.
- Spiral*: as if wound round an axis.
- Spiral arrangement of leaves*, 134.
- Spiral markings on cells*, 39.
- Spiral vessels or ducts*, 46.
- Spireæ*, 416.
- Spithameous*: a span high.
- Spongiolæ, or spongelets*, 80.
- Spongy*: of the texture of sponge.
- Spontaneous movements*, 340, 347.
- Sporadic*: widely dispersed.
- Sporangium*: a spore-case, 337, 500, &c.
- Spore*: the body in Cryptogamous plants which answers to the seed in the Phanogamous, 61, 70, 331.
- Spore-case*, 337.
- Sporiferous*: spore-bearing.
- Sporocarp*: a kind of sporangium, 502.
- Sports*, 356.
- Spore*: a spore, or small spore.
- Sporuliferous*: bearing sporules.
- Spumescens, spumose*: froth-like.
- Spur*: any tubular projection, 278.
- Spurred*: bearing a spur, 278.
- Squamate, squamose, squamiferous*: furnished with scales (*squamæ*).
- Squidnellate*: with or resembling minute and narrow scales (*squamellæ*, 497).
- Squidmiform*: scale-shaped.
- Squidmiform*: like a small scale, or
- Squidmula*, 497.
- Squidmucose*: covered with small scales.
- Squarrose*: where scales, small leaves, or other bodies, spread widely from

- the axis on which they are crowded.
- Squarrose*: diminutive of Squarrose.
- Squash, 423.
- Squills, 493.
- Stalked*: furnished with a stalk, stem, or any lengthened support.
- Stalked glands*, 52.
- Stalklet*: a diminutive or secondary stalk.
- Stamen*: the fertilizing organ of a flower, 223.
- Staminate*, or *stamineal*: relating to the stamens. A *staminate* flower has no pistils, 261.
- Stamiferous*: bearing stamens.
- Staminodium*: an altered and sterile stamen, or a body occupying the place of a stamen.
- Standard*: the posterior petal of a papilionaceous corolla, 253.
- Staphyleaceæ, 409.
- Star-apple, 443.
- Starch, 54, 193.
- Staticæ, 445.
- Station*: the locality or kind of situation in which a plant naturally grows.
- Stellate*, 432.
- Stellate*: starry, star-shaped; arranged in rays, like the points of a star.
- Stellate hairs*, 52.
- Stellulate*: diminutive of *Stellate*.
- Stem*, 91.
- Stemless*: having no obvious stem, 91.
- Stemlet*: a diminutive stem; the first internode of the plumule.
- Sterculiaceæ, 399.
- Sterigma*: the adherent base or downward prolongation of a decurrent leaf.
- Sterile*: barren.
- Sterile flower*: one having no pistils, 261.
- Sterile stamens* or *filaments*: those destitute of anthers, or with the anther imperfect, 281.
- Stigma*: the part of a pistil which receives the pollen, 223, 287.
- Stigmatic*, or *stigmatic*: relating to or bearing the stigma.
- Stings, stinging hairs*, 52.
- Stipe (stipes)*: a stalk of an ovary (267), of a Mushroom (507), and the leaf-stalk of a Fern.
- Stipel*: the stipule of a leaflet; 171, fig. 286.
- Stipellate*: furnished with stipels, 171.
- Stipitate*: having a stipe, 267.
- Stipitiform*: shaped like a stipe.
- Stipulaceous*, *stipular*: belonging to or resembling stipules.
- Stipulate, stipuled*: possessing stipules, 171.
- Stipule*: an accessory part of a leaf, one on each side of the base, 145, 170.
- Stock*, 355.
- Stole, stolon*: a rooting branch, 102.
- Stoloniferous*: bearing stolons.
- Stoma* (plural *stomata*), *stomate*: a breathing-pore, 52, 150.
- Stomatiferous*: bearing stomates.
- Stone*: the endocarp of a drupe.
- Stone-fruit*, 312.
- Stool*: the plant from which layers are propagated.
- Storax, 425, 442.
- Stramineous*: straw-like.
- Strangled*: irregularly contracted.
- Strap-shaped*: see *Ligulate*.
- Stratum*: a layer.
- Strawberry, 416.
- Striate*: marked with longitudinal streaks or furrows (*striae*).
- Strict*: very straight or close, or very upright.
- Strigillose*: same as *Strigose*.
- Strigose*: clothed with sharp and stout close-pressed hairs or scale-like bristles (*striga*).
- Strobilaceous*: relating to, or resembling a
- Strobile*: the cone of a Pine, &c., 319.
- Strobiliferous*: bearing strobiles.
- Strombuliferous*: spirally twisted, like a corkscrew or a strombus.
- Strophole*: same as a Caruncle, 322.
- Structural Botany, 14.
- Strumose*: swollen on one side, bearing a *struma* or wen.
- Strychnine, 57, 434.
- Stupose*: tow-like.
- Style*: a columnar or slender part of the pistil above the ovary, 223, 287.
- Styliferous*: style-bearing.
- Styliform*: style-shaped.
- Stylopodium*: an enlargement or fleshy disk at the base of a style, as in Umbelliferae.
- Styracæ, 442.
- Sub*, as a prefix, means somewhat, or slightly; as
- Subacute*: somewhat acute.
- Subclass, 362.
- Subcordate*: slightly heart-shaped, &c.
- Suberose*: of a corky texture.
- Subgenus, 361, 362.
- Submerged*: growing under water.
- Suborder, 361.
- Subspecies: a marked variety.
- Subtribe, 361.
- Subterranean*: growing beneath the surface of the ground.

- Subulate, subuliform*: awl-shaped; narrow, and tapering to a sharp rigid point, as the leaves of Juniper, &c. 166.
- Succise*: as if cut off at the end.
- Succose, succulent*: juicy.
- Succubous*: the apex of each leaf covered by the base of the next, as in *Jungermannia*.
- Succulent leaves*, 166.
- Sucker*, 102.
- Suffrutescent*: slightly shrubby, 101.
- Suffrutes*: an undershrub.
- Suffruticose*: low and shrubby, or shrubby at the base, 101.
- Sugar*, 53, 193, 194.
- Sulcate*: longitudinally grooved.
- Super-*, above; as
- Super-axillary*: above the axil.
- Superior*: above, 252; also, on the upper side of the flower, i. e. next the common axis (237), as, for example, the vexillum of a papilionaceous corolla (fig. 372, a) is the superior petal.
- Superposed*: one above another.
- Superposition*, 248.
- Supervolute*, 274.
- Supine*: lying flat with face upwards.
- Suppression*: obliteration of parts, 239, 255.
- Supra-*, above; as
- Supra-axillary*: above the axil.
- Supra-decompound*: several times compound.
- Succulose*: producing suckers.
- Succulus*: a sucker, 102.
- Suspended*: hanging from the apex, 297.
- Suspensor* of the embryo, 306.
- Sutural*: relating to the
- Suture*: the seam, or line of opening of a pod, &c., 289.
- Sword-shaped*: a blade with two sharp and nearly parallel edges, tapering to a point, as in *Iris*, fig. 291.
- Syconium, or syconus*: such a fruit as a fig.
- Symmetrical*: equal in the number of all the parts, 232, 239.
- Sympetalous*: becoming somewhat monopetalous by a junction of the base of the petals with the monadelphous stamens, as in the Mallow family.
- Symphyantherous*: same as *Syngenesious*.
- Symphysis*: a growing together of parts.
- Symphystemonous*: the stamens united.
- Synplocinæ*, 443.
- Synanthrous*: united by their anthers; whence *Compositæ* have been named
- Synantheræ*, 435.
- Synclerous*: formed of two or more united carpels, 290.
- Syncoyledonous*: the cotyledons soldered together.
- Synedra*: growing on the angles.
- Synema*: a name for a column of monadelphous filaments.
- Syngenesia*, 513.
- Syngenesious*: stamens united by their anthers; 280, fig. 463.
- Synonyme*: equivalent or superseded names.
- Synonymy*: what relates to synonymes.
- System*, 365, 366.
- Systematic Botany*, 15, 351.
- Tabescent*: wasting or shrivelling.
- Tabular*: flattened horizontally.
- Tail*: any long and slender terminal appendage.
- Tail-pointed*: tipped with a prolonged and weak acumination.
- Tannin, Tannic Acid*, 57.
- Taper-pointed*: same as *Acuminate*.
- Tapioca*, 472.
- Tap-root*, 84.
- Tar*, 480.
- Taro*, 485.
- Tawny*: dull yellowish, verging to brown.
- Taxinæ*, 480.
- Taxology, or Taxonomy*: the department of Botany which relates to classification.
- Tea*, 401.
- Teasels*, 435.
- Teeth* of calyx, corolla, &c., 275; of leaves, 159.
- Tegmen*: the inner seed-coat, 321.
- Tendril*, 102, 167.
- Tepal*: a name proposed for a leaf or part of the perianth when it is uncertain whether it belongs to the calyx or the corolla.
- Teratology*: morphology applied to monstrous states.
- Tercine*: a third coat of the ovule.
- Terete*: long and round, i. e. the cross-section circular.
- Tergeminate*: thrice twin.
- Terminal*: belonging or relating to the summit.
- Terminology*: the same as *Glossology*, 15.
- Ternary*: consisting of three, 239.
- Ternary products*, 53.
- Ternate*: in threes.
- Ternstroemiaceæ*, 401.
- Tessellated*: in checker-work.
- Testa*: the outer seed-coat, 320.
- Testaceous*: brownish-yellow, like unglazed earthen-ware.

- Tetra-*, in Greek compound words: four.
Tetracarpellary: of four carpels.
Tetracarpellary: same as
Tetracarpellary: of four cocci.
Tetradynamia, 512.
Tetradynamous: two of the six stamens shorter than the rest; 281, fig. 407.
Tetragonal, or *tetragonous*: four-angled.
Tetragynia, 515.
Tetragynous: with four pistils or styles, 287.
Tetramerous: the parts in fours, 234, 239.
Tetrandria, 512.
Tetrandrous: with four stamens, 279.
Tetrapetalous: with four petals, 276.
Tetraphyllous: four-leaved, 275.
Tetragynous: quadrangular, with very sharp and salient angles.
Tetrasepalous: with four sepals, 274.
Tetradichous: with four vertical ranks.
Thalamiflorous: with the stamens, &c. inserted in the receptacle, or
Thalamus: the receptacle of a flower.
Thallophytes, 371, 505.
Thallus, 67, 371, 505.
Theca: an anther-cell, 281; or a spore-case, 499, 500.
Thécaphore: same as Gynophore, 267.
Thread-shaped: see Filiform, 166.
Throat: the orifice of a tubular organ, 275, 276.
Thorn, 104.
Thyrse, or *thyrsus*: a thick panicle, 217.
Thyrsoid: like a thyrsus.
Thymelacæ, 467.
Tiente, 434.
Tiliacæ, 399.
Tissue: the fabric of plants, 22.
Tobacco, 456.
Tomato, 456.
Tomentose: clothed with
Tomentum: a close and matted down or wool.
Tongue-shaped: long, fleshy, nearly flat, and rounded at the end.
Tonka-bean, 414.
Tooth: any short and narrow projection.
Toothed: same as Dentate; beset with teeth which on the leaf do not point forwards; 159, fig. 255.
Top-shaped: inversely conical.
Torose: a cylindrical body swollen at intervals.
Tortuous: bent in different directions.
Torulose: somewhat torose.
Torus: the receptacle of the flower, 224.
Tuberculata: cross-barred.
Trachea: a spiral vessel or duct, 46.
Trachenchyma, 46.
Trapezoid, or *trapeziform*: unsymmetrically four-sided, like a trapezium.
Tree, 101.
Tri-, in compound words: three; as
Triadelphous: having the filaments in three sets, 280.
Triandria, 512.
Triandrous: with three stamens, 279.
Triangular: three-angled.
Trianthous: three-flowered.
Tribe, 361.
Tricarpellary: of three carpels.
Tricarpous: with three ovaries.
Tricephalous: three-headed.
Trichotomous: branched into threes.
Tricoceous: of three cocci.
Tricuspitate: three-pointed.
Tridentate: three-toothed.
Triennial: lasting three years.
Trifarious: in three vertical ranks.
Trifid: three-cleft; 159, fig. 265.
Trifoliate: three-leaved.
Trifoliolate: of three leaflets.
Trifurcate: three-forked.
Trigamous: having three sorts of flowers.
Trigonal, or *trigonus*: three-angled.
Trigynia, 515.
Trigynous: with three pistils or styles, 287.
Trijugate: three-paired.
Trilateral: three-sided.
Trilliaceæ, 493.
Trilobate: three-lobed.
Trilocular: three-celled.
Trimerous: the parts in threes; 234, 239, fig. 353.
Trinerved: three-nerved.
Trinodal: of three nodes or joints.
Tricecia, 516.
Triaccous, or *trioceous*: having staminate, pistillate, and perfect flowers on three different plants.
Triovulate: having three ovules.
Tripartite: capable of splitting into three.
Tripartite: three-parted.
Tripetalous: of three petals, 276.
Triphyllous: three-leaved, 275.
Triptunate: thrice pinnate, 164.
Tripinatifid: thrice pinnatifid, 161.
Triple-ribbed, or *nerved*: same as
Tripli-nerved, 155.
Tripterous: three-winged.
Triquetrous: with three salient angles.
Triseppalous: of three sepals, 274.
Triserial, or *triseriate*: in three horizontal ranks.
Tristichous: in three vertical ranks, 134.
Tristigmatic: with three stigmas.
Tristylous: with three styles.

- Trisulcate*: three-grooved.
Triternate: thrice ternate, 164.
Trivial name: the popular name; or the specific name.
Trochlear: pulley-shaped.
Tropaeolaceæ, 404.
Trophosperm: the placenta.
Tropical: growing near or between the tropics.
Trumpet-shaped: tubular, with the summit dilated.
Truncate: as if cut off at the end; 162, fig. 271.
Trunk: a main stem.
Tube: the portion of a calyx, corolla, &c. formed by the union of the sepals, petals, &c., 275.
Tuber: a short and thickened subterranean branch, 107.
Tubercle: a small tuber, or an excrescence.
Tubercled: bearing excrescences.
Tuberiferous: bearing tubers.
Tuberous: tuber-like; 85, fig. 139.
Tubulose, tubular: having a tube, or tube-shaped, as the corolla of *Trumpet Honeysuckle*, &c., 277.
Tubulifloræ, 436.
Tumid: somewhat inflated.
Tunicate: having an accessory covering (tunic).
Tunicated bulb, 109.
Turbinate: top-shaped.
Turio, turions: the early state of a sucker or subterranean shoot, as an *Asparagus*-shoot, 95.
Turneric, 490.
Turneraceæ, 422.
Turnip-shaped: see *Napiform*, 84.
Turnsole, 473.
Turpentine, 57, 480.
Twin: in pairs.
Twining: winding spirally round a support, 102.
Two-lipped, 255.
Type: the pattern or ideal plan, 231, 238.
Typhaceæ, 485.
Typical: representing the type or plan.
Uliginose: growing in marshes.
Ulmaceæ, 474.
Ulmine, Ulmic Acid, 57.
Umbel: an umbrella-shaped inflorescence, 212.
Umbellate, umbelliform: in umbels.
Umbellet: a secondary or partial umbel, 216.
Umbelliferæ, 425.
Umbelliferous: bearing umbels.
Umbilicate: depressed in the centre, like the navel.
Umbilicus: the hilum of a seed; a central depression.
Umbonate: bearing an umbo or boss, a central projection.
Umbraçuliform: umbrella-shaped.
Unarmed: destitute of prickles, spines, &c.
Uncate: hooked.
Unciform, or uncinatè: hooked.
Undate, or undulate: wavy.
Undershrub, 101.
Unequally pinnate: same as *imparipinnate*, 163.
Unguiculate: furnished with a claw (*unguis*), as the petals of *Saponaria*, 276, fig. 449, &c.
Uni-, in Latin compounds: one.
Unicellular: one-celled, 61.
Uniflorous: one-flowered.
Unifoliate: one-leaved.
Unifoliolate: with one leaflet.
Unjugate: of only one pair, 164.
Unilabiate: one-lipped.
Unilateral: one-sided: either all disposed on one side of an axis, or turned to one side.
Unilocular: one-celled.
Uninerveatè: one-nerved.
Uniovalate: one-ovuled.
Unipetalous: having only one petal, as in *Amorpha*, fig. 395.
Uniserial, or uniseriate: in one horizontal row or whorl.
Unisexual: having stamens only or pistils only, 261.
Univalved: of one piece; one-valved.
Universal: same as *General*.
Upas, 475.
Urceolate: pitcher-shaped or urn-shaped; i. e. hollow and contracted at the mouth.
Urticaceæ, 473.
Utricle: a small bladdery fruit, 314.
Utricular: bladder-like.
Utriculariaceæ, or Utricularinæ: same as *Lentibulaceæ*, 445.
Utriculiform: shaped like a little bottle.
Utriculose: bearing *utriculi*, or bladders.
Uvulariæ, 494.
Vacciniæ, or Vacciniaceæ, 439.
Vagina: the sheath of a leaf, &c.
Vaginant: sheathing.
Vaginate: sheathed.
Vaginula: a little sheath, as that around the sporangium of *Peat Moss*.
Vagynulate: with a *vaginula*.
Vague: in no definite order or direction.
Valerian, 434.
Valerianaceæ, 434.
Vallècular: the intervals between the ridges of the fruit of *Umbelliferæ*.

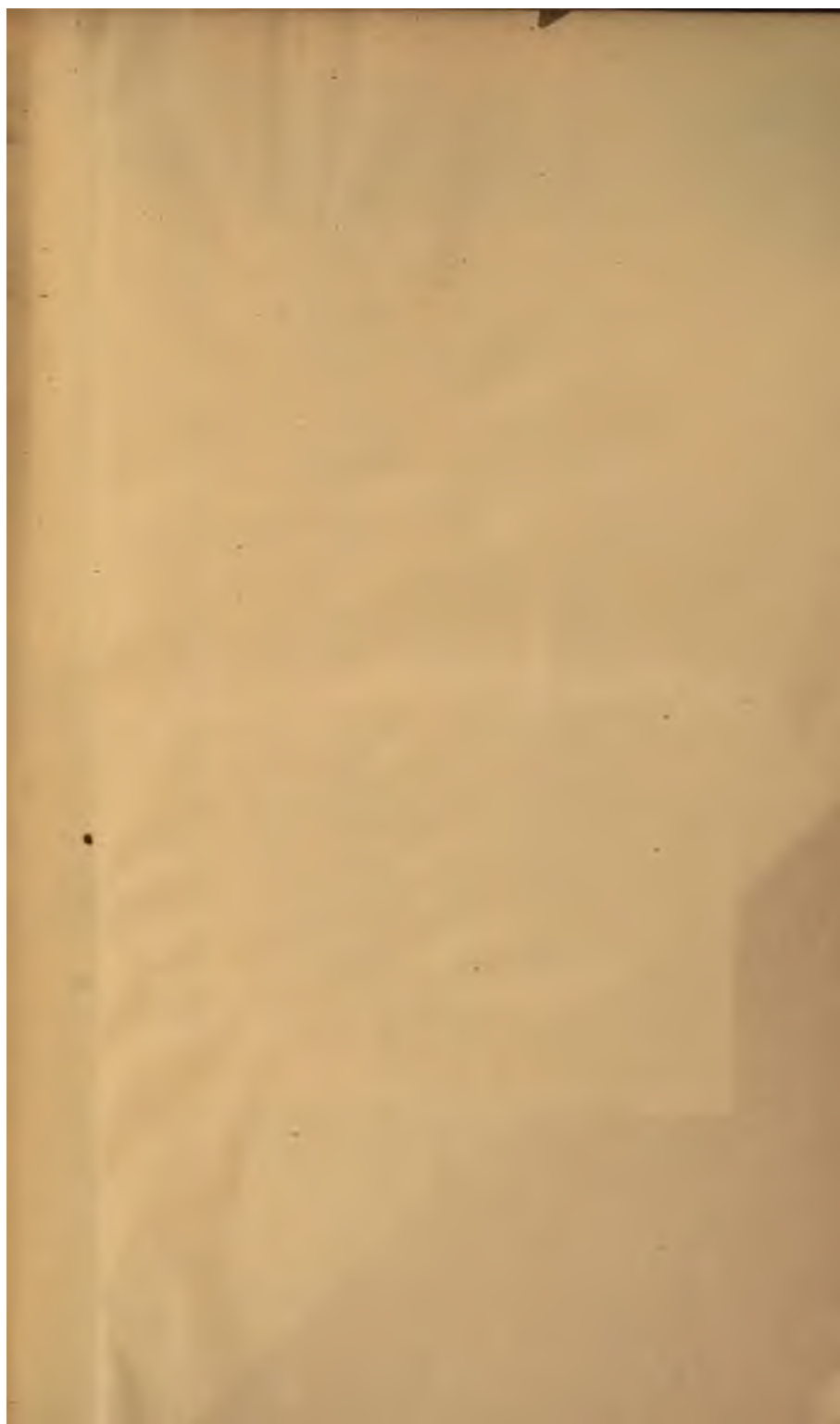
- Valvate* or *valvular* aestivation, &c.: where the parts meet by their edges without overlapping, 144, 273.
- Valve*: a door, or portion into which a pod, &c. separates in dehiscence; also a piece or leaf of a spathe, &c.
- Valved*: opening by valves.
- Vanilla*, 489.
- Variiegated*: having one or two colors disposed in patches.
- Varieties*, 355.
- Vascular*: relating to or furnished with vessels.
- Vascular Plants*, 68.
- Vascular or vasiform tissue*, 40, 45.
- Vasculum*: same as *Ascidium*.
- Vegetable Ivory*, 484.
- Vegetable Physiology and Anatomy*, 14.
- Veil*: see *Calyptra*.
- Veined*: furnished with slender vascular or woody bundles, especially with branching ones, or
- Veins*, 145, 155.
- Veinless*: destitute of apparent veins.
- Veinlets*: the smaller ramifications of veins, 155.
- Velate*: veiled.
- Velutinous*: velvety; covered with very fine and close soft hairs, so that the surface resembles velvet to the touch.
- Venation*: the mode of veining, 154.
- Venose*: veiny; abounding in veins.
- Ventral*: relating to the inner side of a simple pistil, viz. that next the axis.
- Ventral suture*: the inner suture, 289.
- Ventricose*: big-bellied; swelling out.
- Ventriculose*: somewhat ventricose.
- Venulose*: abounding in veinlets.
- Veratria*, 494.
- Verbenaceæ*, 449.
- Vermicular*: worm-like, in shape or appearance.
- Vernal*: belonging to spring.
- Vernation*: the disposition of leaves in the bud, 143.
- Verrucose*: varnished.
- Verrucose*: warty.
- Verruculose*: studded with little warts.
- Versatile*: swinging to and fro; 282, fig. 471.
- Vertex*: the summit.
- Vertical*: perpendicular, lengthwise.
- Vertical leaves*, 165.
- Vertical tissue or system*, 45, 50, 112.
- Vérticil*, or *verticel*: a whorl, 92, 134.
- Verticillaster*: the pair of dense cymes forming an apparent verticil in most *Labiata*, 221.
- Verticillate*: whorled, 133, 142, 221.
- Vesicle*: a little bladder.
- Vesicular*: as if composed of little bladders.
- Vespertine*: appearing or expanding in the early evening.
- Vessels*, 40.
- Vexillary aestivation*, 271.
- Vexillary*: pertaining to the
- Vexillum*: the standard of a papilionaceous corolla; 253, fig. 392, a.
- Villose*, or *villous*: shaggy with long and soft hairs, or *villosity*.
- Vimineous*: bearing or resembling long and flexible twigs, like wicker.
- Vine*: any trailing, climbing, or twining stem. *The Vine*, originally, is the Grape-vine.
- Violacæ*, or *Violariæ*, 392.
- Virescent*: somewhat green (*virens*).
- Virgate*: twig-like; wand-like.
- Virulescent*: same as *Virescent*.
- Viscid*, *viscous*: sticky from a tenacious secretion.
- Vitacæ*, 407.
- Vitellus*: the thickened embryo-sac persistent in the seed, as in *Saururus* and *Brasenia*.
- Viticulose*: producing small suckers or stolons (*viticula*).
- Vittæ* (fillets): the oil-receptacles of the fruit of *Umbellifera*, 426.
- Vittate*: bearing vittæ: marked with longitudinal stripes or fillets, 426.
- Viviparous*: germinating from the seed (330), or sprouting from a bulb, &c., while still attached to the parent plant.
- Voluble*: twining, 102.
- Volute*: rolled up.
- Volva*: the wrapper of *Fungi*, 507.
- Walnut*, 476.
- Wavy*: see *Undulate*.
- Wax*, 56.
- Waxy*: resembling beeswax in appearance or consistence.
- Wedge-shaped*: see *Cuneate*.
- Wheat*, 498.
- Wheel-shaped*: a corolla or calyx with a very short tube and a flat-spreading border; 278, fig. 454.
- Whorl*: a set of organs arranged in a circle round an axis, 92, 134, 221.
- Whorled*: disposed in whorls.
- Whortleberry*, 439.
- Wild*: growing spontaneously.
- Wing*: any membranous expansion. Also the two side petals of a papilionaceous corolla; 253, fig. 392, b.

- Winged*: provided with wings.
Winteræ (or *Winteracæ*), 381.
Winter's Bark, 381.
Withering: see *Marcescent*.
Wood, 119.
Woody tissue or *fibre*, 40.
Woolly: clothed with long and curling,
or matted, soft hairs or wool.
Worm-seed, 465.
- Xyridacæ*, 496.
Yam, 492.
Zanthoxylacæ, or *Zanthoxyleæ*, 406.
Zingiberacæ, 489.
Zoospores: free-moving spores of cer-
tain Algæ; 336, fig. 637, 644.
Zygophyllacæ, 404.

THE END.

1. The first part of the document is a list of names and addresses of the members of the committee.

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